UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1937

PREPARED BY THE

OFFICE OF EXPERIMENT STATIONS

For sale by the Superintendent of Documents, Washington, D. C. - - - - - Price 25 cents

OFFICE OF EXPERIMENT STATIONS

JAMES T. JARDINE, Chief

ADMINISTRATIVE AND ADVISORY RELATIONS WITH THE STATE EXPERIMENT STATIONS

J. T. JARDINE, H. P. BARSS, W. H. BEAL, F. D. FROMME, G. HAINES, F. G. HARDEN, H. W. MARSTON, J. I. SCHULTE, SYBIL L. SMITH, H. M. STEECE, R. W. TRULLINGER, J. W. WELLINGTON, R. Y. WINTERS, B. YOUNGBLOOD

DIVISION OF INSULAR STATIONS

JAMES T. JARDINE, Chief

Hawaii: L. A. HENKE, Acting Director.
Puerto Rico: ATHERTON LEE, Director.

EXPERIMENT STATION RECORD

HOWARD LAWTON KNIGHT, Editor

Agricultural and Biological Chemistry—H. C. WATERMAN and MABEL A. DICKSON.
Agricultural Meteorology—W. H. BEAL.
Soils and Fertilizers—H. C. WATERMAN.
Agricultural Botany, Diseases of Plants—H. P. BARSS and F. V. RAND.
Genetics—G. HAINES, H. M. STEECE, and J. W. WELLINGTON.
Field Crops—H. M. STEECE.
Horticulture, Forestry—J. W. WELLINGTON.
Economic Zoology and Entomology, Veterinary Medicine—W. A. HOOKER.
Animal Husbandry, Dairying, and Dairy Farming—H. W. MARSTON and E. C. ELTING.
Agricultural Engineering—R. W. TRULLINGER.
Agricultural Economics—F. G. HARDEN and B. YOUNGBLOOD.
Rural Sociology—B. YOUNGBLOOD and F. G. HARDEN.
Agricultural and Home Economics Education—F. G. HARDEN.
Foods and Human Nutrition, Home Management and Equipment—SYBIL L. SMITH and MABEL A. DICKSON.
Textiles and Clothing—MABEL A. DICKSON and H. M. STEECE.
Indexing—MARTHA C. GUNDLACH.
Cooperation with *Biological Abstracts*—F. V. RAND.

LIBRARY

(Affiliated with the Department of Agriculture Library and cooperating with the Extension Service)

CORA L. FELDKAMP, Librarian in Charge

UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

Washington, D. C. July 1938

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1937

By J. T. Jardine and W. H. Beal [1]

CONTENTS

INTRODUCTION

The outstanding developments in experiment station work during the year ended June 30, 1937, were expanding activities, with increased funds and facilities, and extension and strengthening of cooperative relations of the stations with the Department and with other agencies interested in agricultural research, as exemplified in a large number of projects and cooperative agreements proposed and approved (p. 6) and in progress in establishment and operation of regional research laboratories (p. 7). There was a most gratifying development of a widespread and helpful spirit of cooperation.

Along with increased activity and cooperation there was greater stabilization and adjustment of research projects and programs making for more efficient use of available funds, facilities, and personnel in the solution of fundamental and long-time problems of wide common interest as well as of special problems of more immediate regional or local interest.

[1] With the collaboration of other members of the Office staff.

INCOME

The total income of the experiment stations from all sources during the year ended June 30, 1937, was something over $17,690,000, of which $5,620,000 was derived from Federal sources as compared with $4,995,000 from such sources for the previous year.

FEDERAL SOURCES

Under the Hatch, Adams, and Purnell Acts each State received $90,000, Alaska $15,000, Hawaii $50,000, and Puerto Rico $35,000. The $1,200,000 provided for the States under the Bankhead-Jones Act for the fiscal year 1937 and the $1,800,000 so provided for the year 1938 were allotted on the basis of the rural populations of the respective States, as specified by the act and shown in table 1.

TABLE 1.—*Bankhead-Jones allotments to stations, 1937 and 1938*

Station	1937	1938	Station	1937	1938
Alabama	$41,347.56	$62,021.34	Nevada	$1,230.32	$1,845.48
Alaska	1,118.24	1,677.36	New Hampshire	4,178,60	6,267.90
Arizona	6,211.28	9,316.92	New Jersey	15,262.92	22,894.38
Arkansas	31,991.60	47,987.40	New Mexico	6,880.50	10,320.75
California	32,970.98	49,456.47	New York:		
Colorado	11,215.48	16,823.22	Cornell	40,424.24	60,636.36
Connecticut:			State	4,491.58	6,737.37
State	5,164.52	7,746.78	North Carolina	51,314.00	76,971.00
Storrs	5,164.52	7,746.78	North Dakota	12,337.88	18,506.82
Delaware	2,505.10	3,757.65	Ohio	46,507.38	69,761.07
Florida	15,400.82	23,101.23	Oklahoma	34,225.42	51,338.13
Georgia	43,761.46	65,642.19	Oregon	10,087.90	15,131.85
Hawaii	4,593.20	6,889.80	Pennsylvania	67,344.76	101,017.14
Idaho	6,859.28	10,288.92	Puerto Rico	24,276.08	36,414.12
Illinois	43,368.26	65,052.39	Rhode Island	1,131.92	1,697.88
Indiana	31,361.30	47,041.95	South Carolina	29,732.48	44,598.72
Iowa	32,427.32	48,640.98	South Dakota	12,216.22	18,324.33
Kansas	25,025.48	37,538.22	Tennessee	37,391.94	56,087.91
Kentucky	39,469.02	59,203.53	Texas	74,682.38	112,023.57
Louisiana	27,566.72	41,350.08	Utah	5,251.84	7,877.76
Maine	10,346.08	15,519.12	Vermont	5,235.80	7,853.70
Maryland	14,275.24	21,412.86	Virginia	35,572.28	53,358.42
Massachusetts	9,091.10	13,636.65	Washington	14,757.86	22,136.79
Michigan	33,483.92	50,225.88	West Virginia	26,906.72	40,360.08
Minnesota	28,398.82	42,598.23	Wisconsin	30,112.44	45,168.66
Mississippi	36,325.70	54,488.55	Wyoming	3,379.76	5,069.64
Missouri	38,483.90	57,725.85			
Montana	7,751.58	11,627.37	Total	1,200,000.00	1,800,000.00
Nebraska	19,388.30	29,082.45			

NON-FEDERAL SOURCES

The income of the stations from other than Federal sources during 1936 and 1937 is shown in table 2.

TABLE 2.—*Income of the experiment stations from other than Federal sources for the fiscal years 1936 and 1937*

Station	1936	1937	Station	1936	1937
Alabama	$270,158.54	$300,526.42	Delaware	$40,781,26	$42,764.90
Alaska	8,633.50	9,210.97	Florida	423,330.84	473,019.27
Arizona	100,298.42	107,794.72	Georgia	39,793.34	56,081.05
Arkansas	81,526.71	92,943.02	Hawaii	37,703.40	46,468.33
California	926,767.62	959,146.17	Idaho	36,773.13	54,416.56
Colorado	181,063.64	178,683.16	Illinois	417,057.35	435,852.95
Connecticut:			Indiana	817,732.07	958,534.10
State	235,065.90	246,952.67	Iowa	265,675.01	292,066.89
Storrs	44,319.03	48,933.04	Kansas	192,266.59	188,863.78

TABLE 2.—*Income of the experiment stations from other than Federal sources for the fiscal years 1936 and 1937*—Continued

Station	1936	1937	Station	1936	1987
Kentucky	$294,965.54	$306,448.77	Ohio	$815,215.92	$662,669.18
Louisiana	117,876.58	121,072.18	Oklahoma	142,613.94	161,639.80
Maine	56,359.79	65,105.02	Oregon	229,842.34	423,786.16
Maryland	112,225.31	103,233.15	Pennsylvania	155,839.57	172,210.32
Massachusetts	258,886.96	290,076.94	Puerto Rico	121,355.00	136,447.44
Michigan	266,064.57	268,676.13	Rhode Island	8,398.92	9,816.41
Minnesota	430,279.77	421,088.48	South Carolina	158,007.59	183,344.23
Mississippi	161,194.38	231,444.11	South Dakota	45,698.65	55,955.72
Missouri	156,769.34	167,971.52	Tennessee	38,278.22	61,807.77
Montana	135,579.20	149,774.89	Texas	611,760.82	589,103.58
Nebraska	184,914.55	202,245.19	Utah	56,511.00	57,051.30
Nevada	13,357.07	10,019.51	Vermont	24,233.37	25,931.22
New Hampshire	58,214.60	51,591.08	Virginia	92,964.54	97,818.95
New Jersey	455,192.50	459,982.25	Washington	116,260.66	125,223.45
New Mexico	54,417.63	55,772.04	West Virginia	87,626.60	114,107.88
New York:			Wisconsin	407,237.34	414,186.00
Cornell	625,207.36	646,079.34	Wyoming	124,598.58	127,383.64
State	377,073.50	379,536.39			
North Carolina	144,763.66	148,646.17	Total	11,361,178.71	12,074,252.72
North Dakota	102,446.99	84,748.51			

The income of the stations from other than Federal sources, $12,074,253, was about 68 percent of the total, and $713,074, or approximately 6.2 percent more than for the preceding year. The greater non-Federal income for the year 1937 resulted from increases of $179,546 in the amount of balances carried over from the preceding year; $163,046 in State appropriations and allotments; $77,447 in fees; $131,208 in sales receipts; $75,164 in special endowments, industrial fellowships, etc.; and $86,663 in miscellaneous income. Of the 53 experiment stations 44 reported an increase for the year in the support from State and other non-Federal sources, and the reduction in income from these sources reported by the 10 other stations was, in most cases, not very significant. The contribution of the Federal Government for the support of the stations for the year was approximately $1 for every $2.15 received from non-Federal sources.

BANKHEAD-JONES OFFSETS

The Bankhead-Jones offsets from State sources for 1937 are shown in table 3.

TABLE 3.—*State Bankhead-Jones offsets, 1937*

Station	Offset	Station	Offset	Station	Offset
Alabama	$41,347.56	Louisiana	$27,566.72	Ohio	$498,459.54
Alaska	1,118.24	Maine	10,346.08	Oklahoma	57,492.76
Arizona	7,192.08	Maryland	14,441.93	Oregon	10,087.90
Arkansas	46,768.34	Massachusetts	10,422.57	Pennsylvania	67,344.76
California	32,970.98	Michigan	33,483.92	Puerto Rico	24,276.08
Colorado	11,215.48	Minnesota	33,843.12	Rhode Island	1,131.92
Connecticut:		Mississippi	36,325.70	South Carolina	29,762.15
State	5,164.52	Missouri	38,483.90	South Dakota	12,259.69
Storrs	5,372.31	Montana	7,798.38	Tennessee	61,807.77
Delaware	2,505.10	Nebraska	19,389.55	Texas	74,682.38
Florida	19,646.80	Nevada	1,230.32	Utah	5,956.97
Georgia	56,380.79	New Hampshire	4,178.60	Vermont	5,235.80
Hawaii	4,594.20	New Jersey	18,386.75	Virginia	38,025.18
Idaho	6,859.28	New Mexico	6,880.50	Washington	15,935.57
Illinois	43,368.26	New York:		West Virginia	26,907.23
Indiana	33,764.64	Cornell	40,424.24	Wisconsin	30,112.44
Iowa	33,655.50	State	4,784.27	Wyoming	3,379.76
Kansas	25,200.46	North Carolina	133,249.06		
Kentucky	40,879.09	North Dakota	15,229.26	Total	1,837,326.40

Table 3 shows total State offsets amounting to $1,837,326, whereas only $1,200,000 was required for this purpose by the terms of the Bankhead-Jones Act. All of the States met their required offsets, and many of them far exceeded them (table 1).

Details of income and expenditures of the experiment stations during the fiscal year 1937 will be found on pages 195 to 213.

IMPROVED FACILITIES FOR RESEARCH

There was noteworthy improvement of station equipment and facilities for research, particularly offices for the research staffs and provision for laboratory and controlled experiments. The expenditures for additions to equipment for the stations as a whole for 1937 amounted to $1,233,161 as compared with $1,781,321 in 1936. Provision for libraries was $49,207 as compared with $58,704 for the previous year. A few typical examples of recent improvements in station facilities for research, particularly in physical plant, are as follows:

Greenhouses and greenhouse equipment so necessary for adequate control in conducting experiments were supplied or provided for at a number of stations during the year. The Arizona College of Agriculture completed six greenhouse units, with a head house, for the use of various departments requiring this type of equipment. A greenhouse built at the Missouri Station as a Works Progress Administration project, at a cost of $14,000, furnishes about 3,000 square feet of space for investigation in plant pathology, plant physiology, and general botany. A State appropriation of $30,000 provided for the construction at the New York (Cornell) Station of two greenhouses, each 35 by 100 feet, for use in potato research by the departments of plant pathology and plant breeding. The plans of these houses call for partitioning into several sections, the construction of tiled beds for steam sterilization, and the installation of blower fans for forced-air ventilation. Several small gasproof sections will be constructed for studying the virus diseases of potatoes. The Pennsylvania Station made preparations for the erection of a greenhouse 30 by 150 feet for research in horticulture. The plans call for a division of the structure into four sections, of which the two larger ones are to be used for work with potatoes and the two smaller ones for vegetable crop studies.

Among other structures arranged or planned by the stations during the year may be mentioned the preparation of plans by the Indiana Station for an addition to the horticultural building and for an agricultural chemistry building to cost $175,000 and $145,000, respectively. At the Kentucky College of Agriculture and Experiment Station the construction of a home economics, bacteriology, and zoology building, to cost $185,000, was authorized. The Missouri Station, at a cost of $1,500, provided a two-story storage unit for the soils and crops department. In conformity with the plan for construction of cabins for the protection of snow surveyors, the Nevada Station erected such a shelter cabin during the year midway between Jarbidge and Marys River Basin. Cornell University built on the top of Fernow Hall, which houses the department of ornithology, an experimental aviary, a metal structure with large wire cages containing smaller shelters to protect the birds and to enable bird experts to carry on bird migra-

tion and other studies and to record the results. A root house, 20 by 36 by 8 feet, for storing breeding stocks of potatoes, nursery stocks, and other miscellaneous materials in connection with its research work, was completed at the North Dakota Station. The buildings of the Regional Laboratory for Pasture Research at the Pennsylvania Station were completed, and the laboratory was dedicated May 4, 1937. The Virginia Station completed and equipped a building for work in agricultural and household engineering; and near Chatham a field laboratory for the study of tobacco diseases.

Continued interest was shown in the extension of station work on agricultural problems to meet the needs of particular localities and agricultural groups. The 1937 General Assembly of Arkansas made an appropriation for the establishment of the fourth substation in the State, designated the Livestock and Forestry Branch Station, and located at Batesville, in the eastern Ozark section. The purpose of this station, with 3,000 acres of land at its disposal, is to study farming practices adaptable to lands with gentle to steep slopes and low or depleted fertility. About 2,000 acres are to be devoted to work with small grains and forage crops, grasses, and other pasture plants, and 1,000 acres to experimental work in forestry. A 30-acre tract was transferred to the Hawaii Station for use as a substation. Farmers, businessmen, and city people made contributions for the purchase of a farm of 120 acres, 8 miles from Vandalia, Ill., for the study by the Illinois Station of crop and soil problems in the southern part of the State. For experimental purposes this land has the advantage that it was farmed for a century with no treatment whatever. For the Kansas Station the State legislature included in the appropriation for the biennium beginning July 1, 1937, $106,700 for the support of the four substations; $42,000 for outlying experiment fields; $30,000 for laboratory equipment; and $30,000 for research on diseases of livestock. The Missouri Legislature appropriated $14,800 for horticultural experiment field work. Fields have been established in southeast Missouri near Campbell and Charleston; in southwest Missouri near Monett; and in central Missouri near Orrick. The purpose of these fields is to assist producers of fruits, vegetables, and truck crops in the solution of their cultural, harvesting, and handling problems in localities where these crops can be and are being grown extensively. Cornell University purchased a farm of 100 acres adjacent to the campus to extend the program of the physiological field station on experimentally produced nervous diseases in animals under controlled conditions. The North Carolina Legislature appropriated $5,000 for apple research work in the Brushy Mountains of the State. Plans are under way for constructing a field laboratory in cooperation with the Brushy Mountain Fruit Growers Association for research under the direction of the horticultural department of the station and in cooperation with the department of entomology and plant pathology. The Washington Station received a special appropriation of $62,500 for the establishment of a tree-fruit substation in the Wenatchee fruit-growing section.

Other forms of aid to agricultural research and for the promotion of methods and plans for facilitating such activities included an arrangement to designate the Missouri Station to receive the assets of a foundation established by J. C. Penney, a native of Missouri. Under

the provisions, the Foremost Guernsey Association, Inc., was endowed with approximately $300,000, in addition to 1,000 acres of land near Hopewell Junction, N. Y., 352 head of Guernsey cattle, and buildings and equipment. The association is to engage in a long-range program of practical and scientific research intended to advance dairying practices and the development of Guernseys. Before or at the termination of a 60-year period all assets will be turned over to the Missouri Station. In Minnesota a State Potato Improvement Association was formed, with an initial membership of 120 and headquarters at the station at University Farm. The purpose of this association is to improve the potato crop with the spread of information to growers, selection and breeding for increased yield and better quality; and to serve as a clearinghouse for ideas on problems affecting the industry. The Nevada Station, in cooperation with the Forest Service and the Bureau of Agricultural Engineering of the United States Department of Agriculture, inaugurated a study of spring precipitation in the Lamoille Basin to determine the relative rainfall at a higher elevation in terms of precipitation on the basin floor and thereby to evaluate the spring precipitation in forecasting the total run-off. Through the new State Department of Social Security and the State Planning Council of Washington, a fund of $37,000 was allotted for soil surveys for the biennium ending March 31, 1939. The work is to be a part of the project on soil survey and land classification conducted by the Washington Experiment Station in cooperation with the State Planning Council.

RESEARCH PROJECTS AND PROGRAMS

GENERAL

The number of formal station projects increased during the year and now totals about 8,000, besides a large number of important informal undertakings. These projects cover practically every major field of investigation affecting agriculture and rural life and many related interests, including land use; soil and water conservation; pasture improvement; crop adjustment; economical production, distribution, marketing, and use of plant and animal products; improvement of the quality of such products; protection against animal and plant diseases, insects, and other pests; tenancy, taxation, and other matters affecting the efficiency of farm business management and the betterment of the rural home and rural life.

The largest number of projects continued to be in field crops, horticulture, and animal production. Other subjects in which there were a relatively large number of projects were plant pathology, entomology, and soils and fertilizers.

Recent typical accomplishments in these various lines of research are reviewed on pages 14–195.

During the year 501 Adams fund projects, 1,604 Purnell fund projects, and 539 Bankhead-Jones fund projects were reported as active. Of the Adams projects 44 were new and 10 revised, of the Purnell projects 199 were new and 62 revised, and of the Bankhead-Jones projects 181 were new and 16 revised.

SPECIAL PROJECTS, DEPARTMENT OF AGRICULTURE

The special research fund for the Department of Agriculture, authorized by title I of the Bankhead-Jones Act, consists of 40 percent of the total funds authorized by that title. This 40 percent is used as follows: 19.2 percent for research projects of the Department, 20 percent for the establishment and maintenance of regional laboratories and facilities in the major agricultural regions at places selected by the Secretary, and 0.8 percent for administration of allotments to the States. For the fiscal year 1937 the special research fund amounted to $800,000.

The special research program included 34 active projects involving participation of 11 bureaus of the Department. Of these projects seven were new. In the development of the projects every effort was made to secure cooperation of research workers regardless of organization lines. Individual projects involved research workers of as many as three bureaus and seven experiment stations.

REGIONAL LABORATORIES

Following the policy adopted in 1936, three additional regional laboratories were established during the year in accordance with the provisions of the Bankhead-Jones Act. Six such laboratories have now been established for the following purposes:

(1) Research to develop improved varieties of vegetable crop plants having superior adaptation to the southeastern region of the United States, approved November 30, 1935, located near Charleston, S. C., under the leadership of the Bureau of Plant Industry with the cooperation of 13 States. By the close of the fiscal year 1937 the necessary land, buildings, and facilities immediately needed had been secured and were partly in use. Part of the 170 acres of land available had been planted in vegetable crops to test their tolerance to weather conditions and diseases.

(2) Research into the industrial utilization of the soybean and soybean products, approved February 20, 1936, located at the University of Illinois, Urbana, Ill., under the leadership of the Bureau of Chemistry and Soils with the participation of the Bureau of Plant Industry of the Department. By the close of the fiscal year 1937 suitable land and laboratory space had been provided by the University of Illinois and equipment and other facilities assembled. The technical staff had been selected and appointed, and satisfactory relationships were developed with 12 State experiment stations of the north central region.

(3) Investigations relating to pasture improvement in the northeastern region, approved February 20, 1936, located at State College, Pa., under the leadership of the Bureau of Plant Industry, with 12 stations cooperating. Land for buildings and field work had been provided by Pennsylvania State College, and excellent progress was made toward completion of physical plant and other equipment, assembling of experimental material, selection of personnel, and development of the research program and relationships with the regional State stations.

(4) Improvement of swine through breeding methods, approved December 22, 1936, located at Iowa State College, Ames, Iowa, under

the leadership of the Bureau of Animal Industry and involving cooperation of 13 North Central States. Arrangements were made whereby the State stations of the region will furnish physical plant and land facilities and most of the hogs.

(5) Research for development of methods of control of diseases and parasites of domestic animals in the southeastern region, approved February 24, 1937, located at the Alabama Polytechnic Institute, Auburn, Ala., under the leadership of the Bureau of Animal Industry with the participation of 13 stations. The Polytechnic Institute furnished suitable land as a site for the laboratory and necessary outbuildings. Plans and specifications for the buildings and improvements were approved and contracts awarded for their construction before the close of the year.

(6) Improvement of sheep for western ranges through the application of breeding methods, approved February 24, 1937, located at Dubois, Idaho, under the leadership of the Bureau of Animal Industry and involving cooperation of 12 stations. Plans and specifications for the laboratory and other necessary facilities were approved before the end of the fiscal year and contracts awarded for construction of the major units.

COORDINATION AND COOPERATION

With effective cooperation of the specialists of the Department of Agriculture and the State experiment stations, further progress was made during the year in expanding cooperative coordinated research of the Department and the stations. Efforts in this direction were aided especially by increased Bankhead-Jones and State funds and by assignment to the Office of Experiment Stations of the functions of Director of Research and administrator of the Department funds provided by the Bankhead-Jones Act. The State stations continued to work closely with other State agencies and local organized groups, with each other in regional groups, and with this Department individually and in regional and national groups in efforts to plan and coordinate their research.

Nearly 1,200 new or revised formal cooperative research projects between bureaus of the Department and the State experiment stations were approved. These covered nearly 1,000 major research undertakings. All of the State stations and all but one of the research bureaus of the Department again participated. There were also many informal cooperative agreements between organized regional and national groups of stations, and in some cases between such groups and this Department. Some of these informal undertakings were of major importance to specialized phases of agricultural production and rural life.

Typical examples of work approved and undertaken were as follows:

The national study of adjustments in farming by regions and type-of-farming areas from the standpoint of national agricultural adjustment, in which all 48 State stations cooperated with the Bureau of Agricultural Economics, the Agricultural Adjustment Administration, the Soil Conservation Service, the Forest Service, and the Resettlement Administration, was reconsidered and redirected into

more specific studies in relation to agricultural conservation and adjustment.

For each of the six regional laboratories established (p. 7) a cooperative agreement was entered into by the Department and the experiment stations, providing for integration of research at the laboratory with research at the experiment stations.

A study of input as related to output in milk production, undertaken during the year, is typical of cooperative research into broadly important regional or national problems other than at regional laboratories. In this undertaking two of the Department's bureaus and 10 of the experiment stations, together with other organized State groups, participated.

Federal and State agencies completed the national cooperative survey of plant and animal improvement which was begun during the previous year. This provided the basis for material published in the Yearbook of Agriculture for 1937 regarding the character and availability of superior germ plasm in the different groups of economically important plants and animals not covered in the 1936 Yearbook. A similar national cooperative survey of research in soil science and related problems involving all Department bureaus concerned with soils, soil science, and land use, and all of the State stations was undertaken during the year. This cooperative study is intended to bring together all available information on the subject and to serve as a basis for review in the forthcoming Yearbook of the Department, similar to those on plant and animal improvement in previous Yearbooks.

There was expansion of coordination of research at the State stations with that of the Department relating to tobacco and cotton diseases and spray injury. Twelve stations and the Bureau of Plant Industry are now engaged in formal or informal cooperation in the study of the production, improvement, and diseases of cotton.

Cereal crop improvement investigations were extended to include 20 States, and study of machinery for the mechanical application of fertilizers to cotton, potatoes, sugar beets, and canning crops and for the production and harvesting of sugar beets, cotton, and corn was extended to include 15 States.

The memorandum of understanding covering research relationships between the Soil Conservation Service and the State experiment stations, adopted during the previous year, became effective with 45 of the experiment stations during the year 1937.

Cooperative projects in human nutrition have been undertaken by regional groups in the North Central, Northeastern, and Northwestern States under formal memoranda of understanding. The North Central project, organized in 1936, is concerned with various aspects of the nutritional status of college girls, and the projects in the Northeast and Northwest with the more limited field of vitamin C requirements (p. 146) and metabolism of college students. In these 3 projects students of the land-grant institutions of at least 14 States are serving as subjects. In the Northeast there is also a cooperative project dealing with the performance during wear of various textile fabrics, with participation by extension and research workers in a number of States in this region.

A closer connection between research in the States and in the Bureau of Home Economics in the field of household equipment was established during the year. In January 1937 a conference in household equipment, attended by research workers from five State stations, the Bureaus of Home Economics and Agricultural Engineering, the Tennessee Valley Authority, the Works Progress Administration, the Rural Electrification Administration, and specialists of the Office of Experiment Stations, was devoted to the evaluation of present studies in the field, the planning of needed studies, the developing of more effective methods of research, and the drawing of specifications for different types of household equipment based upon research findings. These joint efforts have resulted in a more effective attack on home-equipment problems by the cooperating agencies than has been possible heretofore.

Cooperative studies on other agricultural problems included several important new undertakings, among them studies in animal breeding, plant-disease control, home economics, and farm-home equipment. At a conference initiated by experiment station workers on the root knot nematode problem in February 1937, a permanent coordinating committee, consisting of research workers from this Department and several experiment stations and a specialist from the Office of Experiment Stations, was formed to work out means for more effective group attack on the root knot trouble. A number of State stations and Department entomologists organized the Tobacco Insect Council in July 1937 and launched certain cooperative research projects in the subject.

In numerous other regional and national studies of a long-time character, the Department cooperated with from 4 to 29 experiment stations. The total number of formal cooperative studies per station ranged from 8 to 46.

The essence of cooperation is community of interest and the will to cooperate. This spirit is being realized as never before in the cooperative relations of the Department of Agriculture and the experiment stations and other research agencies, and numerous opportunities for its effective exercise are being found in agreement as to objectives, as well as to the means and methods to be used.

INSULAR STATIONS

The work of the Hawaii and Puerto Rico Stations was administered as heretofore under the supervision of the Office of Experiment Stations. The stations, however, continued to develop a greater degree of autonomy and strengthened and increased their affiliation with local research agencies as well as with bureaus of the Department of Agriculture.

HAWAII STATION

Under the immediate direction of O. C. Magistad, the Hawaii Station made substantial progress during the year in strengthening its organization and personnel, broadening and improving its research work, and developing more effective Federal and Territorial relationships.

Further progress was made in the gradual merging of the Federal and Territorial stations into one research unit, a process which it is

expected will be fully completed in 1938. With this in mind and in accordance with the merger agreement previously entered into, the income of the station from direct Federal sources was reduced from $32,066 in 1936 to $12,066 for the past fiscal year and will cease altogether on June 30, 1938, at which time the station will become a wholly Territorial station, similar to the State agricultural experiment stations, deriving its support from Hatch, Adams, Purnell, Bankhead-Jones, and Territorial funds.

The total income of the station during the year was approximately $316,433. This consisted of $15,000 Hatch funds, $15,000 Adams funds, $20,000 Purnell funds, and $4,593 Bankhead-Jones funds, all of which are Federal-grant funds for agricultural research; $45,360 Territorial funds from all sources; $12,066 direct appropriation for the Federal station through the Department of Agriculture; and approximately $204,414 from the funds originally made available under sugar-processing tax-fund allotments and continued by the Supplemental Appropriation Act, fiscal year 1936 (49 Stat., 1116). In accordance with the original sugar-processing tax orders, these supplemental funds were allotted to seven projects, approximate expenditures on which during the fiscal year 1937 were as follows: Taro investigations, $17,805; liver fluke eradication, $14,439; rat-abatement campaign, $66,593; development of truck farming and improvement of marketing facilities for farm products, $31,560; development of livestock feed, $33,451; development of tropical fruits and nuts, $28,924; and promotion of the poultry industry, $11,642.

The station continued to increase its personnel, add to its facilities for research, and start new lines of work. Substantial progress was made in developing facts to encourage and promote a more diversified and self-sustaining agriculture and home life in Hawaii. As a direct result of research financed by tax-fund order No. 4, taro investigations in the Territory of Hawaii, a corporation was established in the spring of 1937 to manufacture taro flour and other products from the starchy corm of the taro plant. The ranching industry was assisted through work relating to improvement of pastures, importation of new pasture grasses, and feeding experiments with locally produced feeds, including molasses. Progress was made in encouraging propagation of tropical fruit and nut trees to aid the incipient fruit- and nut-production industries to make further advance.

Cooperation with the Bureau of Chemistry and Soils of the Department of Agriculture on a soil survey and on certain chemical problems and with the Bureau of Biological Survey on rodent problems was continued.

PUERTO RICO STATION

The Federal station at Mayaguez, Puerto Rico, made noteworthy progress during the year in strengthening its work and in developing effective cooperative relations with Federal, Territorial, and other research agencies.

The major objectives of the work of the station are to evaluate the agricultural needs and resources of the island, secure better land conservation and use, diversify and make more self-sustaining its agriculture, raise the standards of living of the dense and rapidly increasing population of the island, and to serve as an outpost for the study

of tropical problems of special interest to the continental United States.

The station continued cooperation with the Bureau of Plant Industry of the Department in producing insecticidal plants the essential properties of which may prove valuable as substitutes for some of the insecticides now in common use. Similarly work on quinine plants was continued in cooperation with the same Bureau. The station continued to cooperate with the Bureau of Entomology and Plant Quarantine in the introduction of beneficial insects parasitic or predacious upon crop pests of the island. Further work was also done in cooperation with the Bureau of Animal Industry on animal parasites which are prevalent in the island. A soil-erosion survey was completed by the Soil Conservation Service, and progress was made in introducing protective measures against floods and erosion.

The very promising work on production and utilization of the bamboo was retarded by infestations of the powder-post beetle. However, species of bamboo have been introduced which appear to be resistant to this beetle. The station is making particular effort to multiply and diversify agricultural products to increase income and insure a better living for the people of the island through greater use of home-grown produce and the growing of choice products for mainland markets. The successful work of the station with sugarcane, sweet corn, winter truck crops, and vanilla was continued.

Under a cooperative agreement, the Puerto Rico Reconstruction Administration maintained a workers' reconstruction camp on the upland Las Mesas property of the experiment station during the year to develop methods of soil conservation and land utilization under the conditions of unusual rainfall, steep hillsides, and typical tropical crops of Puerto Rico. The Soil Conservation Service also cooperated in this work.

Satisfactory progress continued to be made in coordinating the work of the Federal station at Mayaguez and that of the Insular station at Rio Piedras.

The regular appropriations for the Federal station at Mayaguez were $57,245. In addition, the station continued responsibility for research undertaken with funds originally made available by Puerto Rico tax-fund order No. 5 and continued by the Supplemental Appropriation Act, fiscal year 1936 (49 Stat. 1116), the funds being available until expended. Expenditures under this fund for the fiscal year 1937 amounted to $33,595, making a total budget of $90,840.

The Insular station at Rio Piedras, cooperating with that at Mayaguez, has set up a large and varied program of research in soils, genetics, agronomy, horticulture, plant pathology, entomology, chemistry and technology, agricultural engineering, and economics. The income of this station for the year was $195,723, of which $136,447 was derived from insular sources and $59,276 from Federal sources—$15,000 each from Hatch and Adams funds, $5,000 from Purnell funds, and $24,276 from Bankhead-Jones funds.

CHANGES IN PERSONNEL

There was no extraordinary turn-over in personnel of the experiment stations during the fiscal year 1937. The total number of major personnel changes approximated 106, as compared with 124 during

the previous year. However, recent changes in directorships have been unusually large.

Four changes occurred in directorships at the stations: In Alaska the positions of director of the station and director of the extension service were combined, the extension director, L. T. Oldroyd, succeeding G. W. Gasser as station director. In October 1936 P. S. Burgess, director of the Arizona Station, was elected president of the University of Arizona and R. S. Hawkins, head of the agronomy department, was appointed to serve as acting director. C. G. Williams, director of the Ohio Station, retired June 30 and was succeeded by Edmund Secrest, the associate director. The Oklahoma Station reported the death of its director, C. P. Blackwell, which occurred March 4, 1937. L. S. Ellis was named as acting director.

The total number of technical employees of the stations increased from 3,818 in 1936 to 3,924 in 1937.

A partial study of the personnel situation made during the year indicated that part-time station service is decreasing and that a higher degree of training and qualification for research is being required.

PUBLICATIONS

The stations issued 735 publications of the regular series during the past year as compared with 770 the previous year. Classified by scientific subjects these publications fall into the following groups: Meteorology, 11; soils and fertilizers, 41; field crops, 84; horticulture, 68; forestry, 4; plant diseases, 45; entomology and zoology, 56; foods and human nutrition, 16; rural home management, 8; animal production, 68; dairying, 44; diseases of livestock, 33; agricultural engineering, 35; economics and sociology, 115; and annual reports and miscellaneous publications, 107. Classified by major objectives of the work, the publications, exclusive of certain purely regulatory and service publications, may be grouped approximately as follows: Improvement in crop production and products, 356; improvement in animal production and products, 168; and improvement in rural economic and social conditions, 140.

In addition to their regular series of publications, the stations contributed to 138 outside technical journals 2,560 articles reporting or based on their work, as compared with 2,665 articles in 100 journals the previous year. Thirty-four stations also contributed or collaborated in 74 articles published in the Journal of Agricultural Research, as compared with 83 articles by 34 stations in 1936. The stations thus published during the year, outside of their regular series, a total of 2,634 articles as compared with 2,748 articles the previous year.

The stations expended for publication during the year $263,672 as compared with $257,024 the previous year. While this was not a large increase, it was in significant contrast with the amounts used for this purpose in the past few years.

There was continued and renewed evidence of a growing purpose to make the results of station investigations more widely and readily understood and applied.

There is an increasing trend toward publication of results of the station work in outside technical journals. Some difficulty has been encountered, however, in providing in a satisfactory way financially for such publication.

In view of the growing demand for station publications, the stations are confronted with a difficult problem to provide a sufficient reserve supply of publications for miscellaneous applicants, especially those engaged in extension and vocational education. It seems quite clear that, if it is possible to do so without too large a proportion of funds available for research going for printing, interstate distribution of station publications should be increased.

SOME RESULTS OF RECENT STATION WORK

The following review of recent station work in various lines, prepared by specialists of the Office of Experiment Stations from current publications of the stations, communications from station directors, and other authoritative sources, presents a few examples of station work considered to be of special significance at the present time. It is necessarily selective and not a complete summary of all recent accomplishments of the stations as a whole or individually. It is hoped, however, that it is fairly representative and will serve to indicate results of research which are of value to urban as well as rural people and in line with national and State as well as local recovery and adjustment policies.

PLANT PRODUCTION AND PRODUCTS

Station research relating to plant production and products is extensive and varied and is constantly increasing in scope and purpose. A few of the great number of examples of recent work of the stations relating to more efficient production of crops of better quality follow.

SOIL FERTILITY AND FERTILIZERS—GENERAL

Maintenance of soil fertility.—Poor systems of cropping and soil management, the Illinois Station, among others, finds, are accompanied not only by rapid decline in crop yields and decrease in plant nutrients but also by changes in the physical condition of the soil, especially the surface soil. Soils which have poor cropping systems are much more subject to injury by erosion than soils under good systems. Good physical condition of the soil can be maintained if good systems of cropping and management are followed.

Organic residues in soils.—Washington and other stations have established the fact that humus formed during the decomposition of plant and other organic residues in the soil contains carbon and nitrogen in a definite ratio which varies somewhat with the soil climate and other conditions. Maintenance of an adequate humus supply in cultivated soils is of utmost importance in soil fertility and soil conservation, and requires that the highly carbonaceous plant residues returned be supplemented with nitrogen sufficient to permit the formation of as much new humus as is being destroyed by cultivation and cropping.

Soils treated with lime and manure, the Pennsylvania Station found, had a smaller accumulation of alkali-soluble humus than similar soil not so treated.

Accumulation of soil nitrogen.—Heavy applications of clover for soil improvement, the Missouri Station finds, can materially build up and mobilize the nitrogen reserve of the soil. The greatest

amount of residual nitrogen occurred where the clover was kept on the surface and not incorporated at once with the soil. In a study of accumulation of nitrates under different crops and cultural practices, the station found that nitrate accumulation was less in a cropped than in a fallow soil but increased with advancing season and rising temperatures. Tillage increased the available nitrogen in the soil, while fertilizers had little effect. Fallow soil receiving 6 tons of straw per acre failed to accumulate nitrates above the level common in soils growing crops. There was a general decline in nitrates with the passage of time, being as much as 50 percent in 13 years in the Missouri Station experiments.

Findings by the Massachusetts Station on the effect of legumes and nonlegumes on the nitrogen content of soils were in accord with accepted facts regarding the synthesis of nitrogen from the air by bacteria. Results with the nonlegume crops were strongly indicative of the presence in the soil of nonsymbiotic micro-organisms which add to the supply of nitrogen available for such crops.

Irradiation of soil with a full-arc mercury lamp for 5 hours was found by the New Jersey Station to have a destructive effect upon nitrifying bacteria, resulting in a decrease of nitrate in the soil. A certain amount of ammonia also disappeared under the treatment.

Phosphorus supply and deficiency.—The Arkansas Station observed no close relationship between soil acidity and increase in availability of phosphorus in rock phosphate but did find that availability of the phosphorus was very closely associated with the fluorine content of the phosphate. It concludes that only phosphates low in fluorine should be used as direct fertilizers.

Testing the fertilizing efficiency of calcined phosphate prepared by the process developed by the Department of Agriculture (B. C. & S.), the Pennsylvania Station found the material to equal superphosphate and greatly surpass untreated rock phosphate as indicated by oats yield and phosphoric acid recovered in the crop. Calcined phosphate also had a high availability as measured by solubility in ammonium citrate, and there was close agreement between the chemical and the vegetation availabilities.

The Vermont Station has found that superphosphate mixed with manure, especially in the stable gutters, saves much of the nitrogen which might otherwise be lost, and also supplies phosphorus needed by most Vermont soils.

A deficiency of phosphorus in alkaline soils, found by the Idaho Station, could not be corrected by application of even the most finely ground raw rock phosphate, although soluble phosphates were very effective for this purpose.

Acid-forming fertilizers.—From a study of the acidity or nonacidity of several brands of fertilizers sold in Vermont, the Vermont Station estimated that it would require an application to Vermont soils of 883 tons of limestone to neutralize the acidity developed by the 10,252 tons of complete fertilizer which were sold in that State in 1936. While nearly 5,000 tons of superphosphates were sold, this material is practically neutral in reaction.

The Virginia Truck Station has shown the advantage of employing limestone supplements with acid-forming fertilizers to prevent accumulation of acidity in soils used for vegetable growing and to increase utilization of the fertilizer constituents supplied.

The yield of nearly all vegetables, the Arkansas Station found, increases as soil acidity is reduced. This was also true for strawberries, although production at pH 6 was nearly as great as at pH 7.

Lime in rotation.—Lime increased the yield of all the crops tested by the Alabama Station in a 2-year rotation of cotton, vetch, corn, and soybeans on sandy soils, regardless of the kind of fertilizer used. The most profitable 2-year addition of lime with proper fertilizers was the 400-pound-per-acre rate, drilled, and the 1-ton-per-acre rate once every 10 years was the most profitable broadcast application.

Toxicity of soil.—During prolonged study of toxic effects of soil acidity on the growth of various plants, the Rhode Island Station found that the retarding effect, so-called aluminum toxicity, of soils on beets and barley, is accentuated by lack of available phosphoric acid due to fixation in the soil by aluminum, and is corrected by application of superphosphate, which not only adds available phosphoric acid but tends to free the fixed phosphoric acid of the soil.

Excessive liming of a Norfolk loamy sand, in investigations by the Alabama Station, resulted in injury to vetch, turnips, oats, cabbage, tomatoes, and soybeans, ending in some cases in a virtual crop failure. Addition of boron to the overlimed soil completely prevented the injurious effect of overliming, which was attributed to boron deficiency.

Experiments by the Mississippi Station showed that light sandy Mississippi soils low in organic matter can be damaged with as little as 200 pounds of commercial arsenate per acre. Applications must be very heavy before damage occurs on heavier soils. Legume crops are the most susceptible to arsenate injury.

The California Station has found thallium sulphate to be very toxic in soils, 30 pounds being capable of sterilizing an acre-inch of average soil. Toxicity was greatest in soils of low fertility but decreased with time and cropping. Thallium-treated barley, as commonly used for ground-squirrel bait, had slight effect on germination or growth of oats planted therewith or on growing plants in a pasture area.

Selenium in soils.—The theory of converter and indicator plants in connection with poisoning of animals with selenium was further confirmed by the Wyoming Station. A number of plants were shown to be positive indicators, that is, selenium can invariably be found in these plants growing on land containing selenium. This was borne out in the case of *Stanleya* spp., *Oonopsis* spp., *Aster cotmutatis*, *A. multiflorus*, and *Xylorhiza parryi* from various widespread areas in Wyoming, Colorado, New Mexico, and South Dakota. The station has shown that a seleniferous soil producing nontoxic grain can be converted into a soil producing toxic grain by growing these indicator and converter plants upon it. The station also has made an intensive study of the occurrence of selenium in soils and vegetation associated with rocks of Permian and Triassic age.

The South Dakota Station published an extensive review of its findings and those of other stations and the Department of Agriculture on the geographical and geological distribution of selenium, selenium content of soils and uptake of plants, selenium poisoning in livestock and its prevention, and its relation to public health.

Reclamation of alkali soils.—The California Station has found that so-called white alkali soils containing a relatively large amount

of soluble salts, mainly chlorides and sulphates of sodium, calcium, and magnesium, can be leached out, provided drainage conditions are favorable, without special treatment with such materials as gypsum and sulphur. On black alkali soils, the station obtained good results from treatment with finely pulverized sulphur under good drainage conditions. For best results, the land should be leveled before the sulphur is mixed with soil by shallow plowing or disking, after which the soil should be irrigated and cultivated as often as is needed to keep it moist and well aerated. The station also confirmed an earlier finding that black alkali soil can be reclaimed economically and effectively by growing the alkali-resistant Bermuda grass. Frequent and rather heavy irrigations during summer months provide conditions favorable for its rapid growth and for the removal of soluble salts. It is believed that pasture provided by the grass during the reclamation process will pay for the carrying costs involved.

Minor plant nutrients.—The value of the so-called trace elements in plant nutrition continued as a popular line of investigation at the Florida, Kentucky, North Carolina, New Jersey, South Carolina, California, and other stations.

The Kentucky Station showed again that boron in limited amounts is an essential mineral nutrient for many plants, although in larger quantities it may prove toxic. Working in a celery field where every plant had been unsalable because of a serious cracking of the stems, the New Jersey Station found that when borax was applied with the fertilizer less than 2 percent of the plants were injured, while 56 percent of the plants grown with fertilizer alone showed cracked stems. Evidently, on some soils in New Jersey, and particularly with certain crops, actual boron deficiency exists, and for maximum yields this element must be included in the fertilizer.

The Wisconsin Station found boron to be essential to the growth of lettuce, and manganese increased the growth of buckwheat in cultures. Copper and manganese increased growth of onions, sweetclover, and potatoes on peat soils, and potatoes responded in yield to zinc. Improvement in quality was apparant in potatoes and onions grown on copper-treated peat. Investigations by the California Station furnished additional evidence that zinc in slight quantities is essential for the higher plants and also for fungi.

Granular fertilizers.—Granular fertilizers now being manufactured are easier to distribute uniformly, absorb less moisture from the air, tend less to cake, do not become dusty in dry weather, and can be distributed in windy weather. In comparative tests with tomatoes, the New York State Station obtained a higher yield with granular fertilizer than with pulverized fertilizer.

Fertilizer application.—Methods of applying fertilizer have gained in importance with the trend toward concentrated materials and heavier applications. Many stations have been cooperating for more than a decade with the Department of Agriculture (B. A. Eng. and B. P. I.), technical societies, and farm-equipment and fertilizer associations, in studies of problems involved in using fertilizer to best advantage in growing field crops, vegetables, and fruits. The best method of application for nearly all row crops, it has been demonstrated, is in bands an inch or two away from the seed and at its

level or just below. This type of placement practically insures against injury to seed or roots from too much salt concentration and tends to lessen the fixation which occurs when fertilizers are intimately mixed throughout the soil. Farm-machinery manufacturers have been designing and producing machinery to apply fertilizers in this manner.

Compost.—In a study of decomposition processes involved when plant materials high in proteins, as alfalfa and clover, and high in carbohydrates, as straw, are mixed in varying proportions, the New Jersey Station found that at 50° C. (122° F.) an excellent compost could be obtained within 30 days from a mixture of alfalfa 40 percent and straw 60 percent. Inoculation of the mixture with compost prepared earlier under similar conditions greatly reduced the necessary incubation period.

Crops grown without soil.—The California Station reports the successful growth of certain crops in shallow tanks containing nutrient solutions. The New Jersey Station has had success with a method in which a constantly renewed nutrient solution is supplied to sand in well-drained benches. In a method developed by the Indiana Station, the nutrient solution is pumped into a watertight bench, filled with coarse sand or good-grade cinders, the excess liquid draining back into the supply tank. Tests indicate that such methods may have definite commercial possibilities for use in greenhouse culture. Suggested advantages include absolute control of nutrients, frequent and complete aeration of roots, economy of fertilizers, few or no soil-borne insect pests, quicker root development, and automatic feeding and watering operations with lowered labor costs.

Soil conservation.—Conditions which contribute to accelerated run-off and soil erosion in prairie, pasture, and cultivated lands are explained on the basis of studies by the Nebraska Station in cooperation with the Department of Agriculture (S. C. S.), and ways of reducing erosion are described. It is stated that under many conditions erosion can be greatly reduced or almost completely controlled with adaptable measures involving a cover of vegetation. One of the chief essentials of erosion control is the increased use of grasses.

The Kentucky Station, in a cooperative study with the Department of Agriculture (A. A. A., B. A. E., and S. C. S.), found that a net loss of about one-third of the topsoil had taken place in farms showing least erosion, and about three-fourths in farms with the most erosion. The least-eroded farms averaged larger yields of crops and their operators earned labor incomes averaging $536 more per farm than the operators of the most-eroded farms. About 30 percent more of the intertilled cropland of the least-eroded farms was covered with growing crops the following winter, and one-third of the most-eroded farms had no cover crops in the fall and winter. Fifty-four percent of the farmers operating the least-eroded farms used limestone to improve the soil as compared with 27 percent on the most-eroded farms. Fertilizer was used for wheat on all the least-eroded farms, and for tobacco on 87 percent.

A survey by the Massachusetts Station, in cooperation with the Department of Agriculture (S. C. S.), showed that moderate sheet erosion and occasional gullies occur on cultivated land in western Massachusetts and that wind erosion is a serious factor in the Con-

necticut Valley. In general, however, soil erosion was not found to be a serious problem in Massachusetts. An average of 12 percent of the area surveyed was in cultivated crops, 36 in pasture, 25 in hay land, 25 in forest, and 2 percent was idle.

A study, by the Vermont Station, of the operation of the 1936 soil conservation program in nine Vermont towns indicates that owners or tenants of large farms, who were farm bureau members, and handled their farms intensively, were more likely to participate in the conservation program than those operating on a smaller scale or less intensively. Participating farmers used considerably more commercial fertilizer in 1936 than in 1935, and had an appreciable increase in the acreage stocked down.

See also page 165.

HENRY M. STEECE.

WEED CONTROL

Effective land utilization and economical crop and livestock production demand the elimination of the serious weed pests that lower crop yields, depreciate farm products, and reduce the actual values of cultivated field and pasture land. Long recognizing the increasing seriousness of the weed menace, the stations, often cooperating with the Department of Agriculture, have extended their efforts in research aimed at eradication or control measures. Many farm, commercial, educational, and regulatory agencies are supporting the research institutions in these endeavors. The Western States Weed Control Board, recently formed among five Western States, exemplifies this trend.

Herbicides.—The merits of different chemicals as weed killers and their effects on the crops and soils were being appraised by various stations.

Although boron compounds are extremely toxic to some plants and may reduce growth and produce characteristic symptoms when in relatively low concentrations in the soil, the California Station found that they will have only limited value in chemical weed control. Klamath weed, injured by high concentrations of salts in the soil solution, was found to be highly susceptible to boron poisoning. Against more tolerant plants and in regions of fertile, recent alluvial soils, the use of boron compounds seemed limited to the coarser soils or gravelly areas; and where annual rainfall exceeds 10 inches, applications may be needed one or more times each year. The station emphasizes that boron compounds must be used with caution near ornamental plants, around orchards or groves of citrus and walnuts, and where a possibility of contaminating irrigation water supplies exists.

Sodium ethyl xanthate, the Minnesota Station and the Department of Agriculture (B. P. I.) showed, has a pronounced toxicity for aerial parts of herbaceous plants without an appreciable corrosive effect on spray equipment.

The New Jersey Station has found sodium sulphocyanate to be effective for killing poison-ivy, dandelion, and plantain. It is much cheaper than ammonium sulphocyanate used for the same purpose and apparently is as effective.

Winter hardiness of weeds.—Rhizomes, i. e., underground root-like stems, from fertilized and unfertilized quackgrass, roots of Canada thistle and field bindweed, and crowns of downy bromegrass, were found by the Michigan Station to become hardier as cold weather came on. Alfalfa roots and crowns could withstand lower temperatures than Canada thistle or bindweed roots. Canada thistle was relatively susceptible to freezing injury. When photosynthesis was prevented in the fall, quackgrass fertilized with nitrogen failed to harden, while unfertilized quackgrass rhizomes hardened considerably, although not as well as under normal conditions. The applicability of certain of these principles in control of quackgrass on a field scale is evident.

Bindweed.—Control of field bindweed or wild morning-glory (*Convolvulus arvensis*) was a major research activity at a number of stations in the Corn Belt and the West. The control method promising to be very effective, according to the South Dakota Station, provides for the introduction into the crop rotation of summer fallow followed by a smother crop of winter rye with repetition for at least two, and probably three, consecutive seasons.

The Minnesota Station finds that if land is fallowed after grain harvest until fall planting time, bindweed may be controlled rather easily. After a short fallow period up to June 15, soybeans planted in rows yielded well and the stand of bindweed was reduced. A single season of fallow until August also made possible the growing of a good stand of alfalfa on land thoroughly infested with bindweed.

The Nebraska Station found that sodium chlorate broadcasted and immediately leached into the soil by watering killed bindweed in bluegrass lawns in a year's time and left the bluegrass relatively uninjured. A total of 5 pounds of sodium chlorate per square rod in 1-pound applications at 2-week intervals gave the best results. Individual treatment with 5 grams of sodium chlorate or light spraying with sodium chlorate solutions of ½, 1, and 2 pounds per gallon at 2-week intervals also resulted in eradication.

Studies of the trend of the root reserves of bindweed under control measures, the Colorado Station reports, emphasized the marked depletion of the total carbohydrates in the roots of plants subjected to systematic cultivation. Prolonged cultivation, either occasional or frequent, caused a significant decrease in the food materials stored in the roots and thus lowered the chances of survival of the plant. This was found true in plants under cultivation at intervals of 3 weeks or less. Some slight additional decrease accompanied increased frequency of cultivation. The station also has shown that cultivation 2 inches deep every 2 weeks is as effective as cultivation oftener and less expensive for control of weeds, particularly bindweed.

Canada thistle.—The futility of any cropping system on irrigated land infested with Canada thistles which does not include at least 3 successive years of alfalfa for hay was shown by the Montana Station. A 6-year rotation of barley (alfalfa), alfalfa 3 years, spring wheat, and potatoes has prevented serious infestation, while all continuously cropped areas and 2-, 3-, and 4-year rotations have been practically taken over by Canada thistles. Heavy infestations may be eradicated completely by 2 years of clean or black fallow on irrigated land.

Crabgrass.—The Ohio Station finds that crabgrass in lawns can be controlled by application of 20 pounds of lead arsenate per 1,000

square feet, if made during late fall or early winter. It was demonstrated that the arsenate prevents germination of the seed, the effect being due to arsenic rather than to the lead.

Nutgrass.—The Alabama Station has succeeded in eradicating nutgrass on Norfolk sandy loam by plowing or disking at intervals of 2 weeks throughout two successive growing seasons. Such treatment during a single growing season destroyed more than 90 percent of the weed. Plowing at 3-week intervals during one growing season was about as effective. As few as four hens could eradicate nutgrass from a $\frac{1}{60}$-acre plat in two growing seasons.

Quackgrass.—At the Michigan Station, quackgrass plowed at early bloom was killed more easily than that plowed either earlier or later. Fertilized grass always grew faster at first after plowing, but was weaker than unfertilized grass after being hoed off once or twice. Rhizomes of quackgrass from plants fertilized with ammonium sulphate sprouted more vigorously and were less able to recover in soil after sprouting than rhizomes from unfertilized soil, were more subject to molds, particularly if somewhat injured by air drying, and were injured more by a period of sprouting before exposure to drought. Quackgrass responded to nitrogen fertilization by producing greater top growth which contained more nitrogen than did unfertilized grass.

Poisonous plants.—A summary of available knowledge concerning poisonous and other injurious plants occurring in Colorado, with all known remedial measures, has been published by the Colorado Station.

A poisonous principle, locoine, of the locoweed (*Astragalus earlei*) has been isolated and its chemical properties determined by the Texas Station.

The Nevada Station has found additional evidence of the poisonous properties of *Astragalus speirocarpus*, a plant commonly found on sheep ranges of western Nevada and eastern California.

See also pages 127, 190.

HENRY M. STEECE.

FIELD CROPS RESEARCH

Demands of the present day agricultural problems of surplus or deficiency production, efficient land utilization, soil conservation, droughts and other crop hazards, the rise of new crops into general culture, and the development of new cultural and harvesting practices and implements are now, more than ever before, directing the course of field crops research by the stations. During the last few years station agronomists have given special attention to weather-crop relations; soil-fertility problems closely associated with crop production and plant composition; availability of essential plant nutrients in the soil, effects of their deficiencies, and effective and economical methods of supplying them to crops; vegetative methods of soil-erosion control; machine-harvesting problems; crop storage and handling; and factors variously affecting market values and technological qualities of the several crops. Less emphasis is placed on the conventional or local yet necessary tests of varieties, fertilizers, and cultural and harvesting practices.

Crop-improvement research aimed at better agronomic characters such as yield, earliness and uniformity of maturity, resistance or

tolerance to drought, plant diseases, insect pests, and lodging, and at technical factors, for example, milling and baking quality in wheat, malting quality in barley, spinning quality of cotton fibers, better oil in soybeans and flax, and improved burn and aroma in tobacco, have continued as major enterprises at many stations, and usually in cooperation with the Bureau of Plant Industry and other bureaus of the Department of Agriculture.

Specialists have summarized the objectives, methods, and accomplishments in the improvement of potatoes, root crops, popcorn, timothy, alfalfa, soybeans, clovers, and miscellaneous grasses and legumes as features of the Yearbook of Agriculture, 1937. This comprehensive cooperative endeavor of the stations and the Department supplements similar information on the improvement of wheat, barley, oats, rice, corn, sorghum, sugarcane, sugar beets, cotton, flax, and tobacco, published in the Yearbook of Agriculture, 1936.

The more fundamental phases of research with field crops have received due consideration. Pertinent examples of such investigations include studies of the physiology of crop plants, the development of barley and wheat spikes and oats panicles, nutrition and morphology of the cotton plant and cotton fiber, anatomy of the tobacco leaf, causes of winter hardiness in cereals and legumes, reproduction in various crop plants, the life histories of weed plants, and the technic of experimentation. All of these studies provide essential information on which to base research with more immediate practical application.

Some examples of recent findings in the course of research with the several field crops are given in the following pages.

COTTON

Definite progress was made in the solution of certain problems of cotton production including factors limiting cotton culture; seed value; varietal improvement; fertilizer formulas, methods of application, and sources of plant food; cultural and irrigation practices and harvest practices; and fiber quality studies.

The limits of cotton culture.—Cotton growing has spread into practically all available areas in the country where there are expectations of profitable production. Missouri, for example, which is on the northern boundary of the Cotton Belt, produced more than 300,000 bales of cotton in 1936. The Missouri Station found the essential features of a cotton variety for that State to be early maturity to escape frost, good lint quality, large bolls to reduce harvest cost and increase storm resistance, high lint percentage, and resistance to wilt and rust. Adapted varieties, good pure seed, early planting, maintenance of soil fertility, good culture, and early harvesting also are considered important. On the other hand, the Oklahoma Station, observing that the annual acre yield of seed cotton, 1924–36, at Goodwell, in the Panhandle, averaged only 202 pounds, concluded that cotton cannot be grown economically in competition with wheat and sorghum in the southern high plains. Early frost and low temperature killed the plants before maturity in four of the years, indicating that the growing season in that area is too cold and short for cotton.

Pure seed.—Production of sea-island cotton in Florida and south Georgia has expanded rapidly during the past several years, due to favorable seasons and unusually low bollweevil infestation. Even if satisfactory yields can be produced, the Georgia Station, cooperating with the Department of Agriculture (B. P. I.), observes that its permanent establishment depends on immediate measures to maintain purity of planting seed. Necessary precautions include planting 1 mile or farther from short cotton, roguing at least twice, picking seed cotton into clean sacks, using a clean gin and clean storage for both seed cotton and seed, and organization of one-variety communities.

The Tennessee Station observed that old seed with proper storage will germinate well, carry less disease, and therefore is preferable for planting as long as viable. The station also finds that the strain number of a variety is important, and to assure purity, seed for planting should be obtained from the originator.

Varieties.—Experiment stations in 10 cotton-producing States, cooperating with the Department of Agriculture (B. P. I.), have been testing 16 cotton varieties chosen for their importance in different sections of the Cotton Belt. Indications are that such characteristics as staple length, lint percent, weight of lint per 100 seed, and lint fineness do not change greatly as environment changes, but yield, time required for germination and to reach the blooming stage, time of opening, and maturity of fiber are modified considerably by local seasonal conditions.

A number of strains of Arkansas Acala, Arkansas Rowden, Roldo Rowden, Stoneville, Delta and Pine Land, Delfos, and Dixie Triumph were consistently among the better producers in Arkansas Station tests.

Recommendations of the North Carolina Station include certain strains of Mexican, Coker, Farm Relief, and Cleveland for the Piedmont; of Farm Relief, Cleveland, Coker, and Mexican for the upper Coastal Plain; of Coker, Foster, and Farm Relief for heavy and poorly drained soils in the lower Coastal Plain; and of Dixie-Triumph, Clevewilt, and Dixie for wilt-infested soils.

The Tennessee Station recommends strains of Stoneville, Delta and Pine Land, Delfos, and Acala, and along the northern border of Tennessee recent strains of Trice. Prolific types have outyielded nonprolific western types, and late maturing varieties are not safely planted.

Cotton fertilizers.—Experiments by the Georgia, North Carolina, South Carolina, and Virginia Stations, cooperating with the Department of Agriculture (B. P. I.), indicated that properly formulated double-strength fertilizers may be as efficient as single-strength fertilizers. The relative efficiency was not affected significantly by differences in content of minor elements. The largest yields generally were obtained with concentrated fertilizers containing acid-forming ammonia salts or soluble nitrogen supplemented with limestone. Properly supplemented concentrated fertilizers, best applied at planting and in bands to the side of the seed, should give good results and reduce costs of cotton production.

The Georgia Station, cooperating with the Department of Agriculture (B. P. I.), and with farmers, obtained the largest returns per

acre from cotton fertilizer furnishing 32 pounds each of nitrogen, phosphoric acid, and potash per acre, equivalent to 533 pounds of a 6–6–6 (NPK) fertilizer. With this application, 76 percent of the total yield increase was estimated as due to nitrogen, 8 to phosphoric acid, and 16 percent to potash. The station also found that fertilizers should contain considerable calcium and magnesium on some soils and possibly a little sulphur. It found no evidence that boron, copper, manganese, or zinc is needed on the average cotton soil. The station also reported basic information from its continued study of the effects of the concentration of ammonium and nitrate nitrogen in the medium upon the growth and metabolism of cotton plants, and the influence of the form of nitrogen used on the boron needs of the plant.

Experiments in several type-of-farming areas indicated to the Arkansas Station that with proper adjustments fertilizers may be used profitably in all parts of the State. A complete fertilizer is always desirable, yet moderate applications usually lead to the best returns. Both nitrogen and phosphorus evidently should be included in all applications unless nitrogen is supplied indirectly. As side dressings, nitrogen may yield high returns in some areas, but if used alone, it may best be applied before planting.

The Louisiana Station has determined the fertilizer needs of cotton on different soil types. Its results suggest 300 pounds per acre of 8–8–8 (NPK) fertilizer on the hill and upland valley soils and 400 pounds of 6–10–7 fertilizer on the loessial bluffs and flatwoods soils east of the Mississippi and as much as 600 pounds of 4–8–6 fertilizer on prairie soils in southwest Louisiana, except in areas where cotton rusts excessively, where a 4–8–10 mixture should be used. On Red River and Mississippi River alluvial soils yield increases followed application of nitrogen and phosphorus but not potassium.

Yields of continuous cotton generally rose for all treatments, 1929–36, on heavy Gila clay soil at the New Mexico Station, especially on manured land. Manure, at rates of 6.25 to 8.5 tons per acre each year, increased the average annual yield of lint cotton, increased average staple length, produced slightly larger bolls, resulted in a slightly lower lint percentage, and delayed maturity, whereas these characters were not affected much by annual applications of minerals.

Studying responses of cotton to various sources of nitrogen, the South Carolina Station observed only slight differences in soil reaction following the use of the several carriers, and that no marked yield differences are to be expected on limed soil with a desirable reaction. At rates of 5 tons per acre each, green vetch produced an average of 2,610 pounds of seed cotton, cow manure 2,325, and no nitrogen 1,449 pounds. Yields from Austrian Winter peas in combination with sodium nitrate indicated that the fertilizer nitrogen could be reduced about 50 percent without affecting yields materially.

Maximum benefits from normal and higher rates of cotton fertilizers, the North Carolina Station found in cooperative experiments with the Department of Agriculture (B. P. I., B. A. Eng.), can be assured by side placement from 2 to 3 inches to the side and from 2 to 3 inches below the level of the seed. Placement to one side of the seed gave about as good results as to both sides. With a normal or heavy application, high in nitrogen or potassium, to avoid injury, the seed should not be placed too close to the fertilizer.

See also page 186.

Spacing.—In experiments of the Alabama Station, spacings providing less than 8,000 and more than 25,000 cotton plants per acre resulted in reduced yields. The Station recommends that cotton be spaced 18 inches apart in the drill with from 1 to 3 plants per hill. Row width, with liberal fertilization, may vary from 2½ to 4½ feet, while under low or moderate fertility conditions row widths should not exceed 3½ feet.

Irrigation requirements.—The highest average lint yield of cotton in experiments by the Texas Station on Miller loam at Iowa Park, where irrigation rates ranged from 2 to 34 acre-inches of water, resulted from use of 30 acre-inches, which included both irrigation and rainfall during the growing season. The total amount of water needed for maximum yields evidently is influenced by seasonal conditions, as amount and distribution of rainfall, humidity, and temperature. The crops seem to need more water in dry, hot years than in more favorable years.

See also page 194.

Fiber quality.—Its studies of effects of exposure of raw cotton in the field led the Texas Station to conclude that the crop should be harvested, so far as practicable, not later than 4 or 5 weeks and preferably within 1 or 2 weeks after opening, to assure a product of high quality in grade, strength, and color.

The Mississippi Station harvested lint cotton early in the season 2.11 times as fast by snapping as by picking, and the ratio rose to 3.91 by the last harvest. The larger-boll types could be harvested fastest by either method. Price premiums decreased on picked cotton with increase in damage due to delayed harvest and rain, while discounts for snapped cotton were usually greatest late in the season. Delayed harvest affected the seed chiefly by increasing the free fatty acid content of the oil and decreasing viability.

Cooperating with the Department of Agriculture (B. A. E.), the North Carolina Station observed that the percentage of gin-damage in cotton is highest when the season begins, being closely related to rainfall, decreases rapidly until November, and remains about the same through December. Practical conclusions are that cotton farmers can improve the grade of their cotton and promote good ginning by bringing cotton in good ginning condition. Cotton should be harvested promptly, but not be picked while wet or too green. Cotton, if picked damp or green, should be allowed to dry before taken to the gin.

Better grades, the Tennessee Station found, generally are obtained from September and October pickings. The length of lint is affected by the moisture content of the soil, an abnormally dry season resulting in shorter staple. A combination of factors within the region may affect the lint.

Fiber studies by the Arkansas Station, involving four varieties representing staple lengths most commonly grown in the Cotton Belt, revealed a genetic basis for the length-diameter relationship, but also that seasonal conditions play an important role. There seemed to be no well-defined relationship of diameter to mean length of the variety. The station has developed a photo-

electric cotton fiber sorter which makes it possible to do the sorting much more rapidly with a high degree of accuracy.

The New Mexico Station observed that certain qualities of lint, as especially denoted by length of lint and percentage of 1⅛-inch+ fibers, are affected by the location of plants, variation apparently due to lack of uniformity of the soil. A new strain of Acala cotton (No. 1064) developed by this station has been found to be earlier and to have a longer staple than regular Acala.

CORN

Improvement.—Continued progress, with striking results, has been made by the different stations, many cooperating with the Department of Agriculture and other stations, in developing new corn varieties and productive hybrids, some characterized by resistance to disease, insect, or drought, and others by peculiar adaptations.

The rapidly expanding acreages of hybrid corn varieties developed by the Minnesota Station, cooperating with the Department (B. P. I.), indicated that the hybrid method of seed production will continue to prove of great value. Minhybrid 301, involving two Minnesota No. 13 inbreds and a later maturing Iowa inbred, has greatly surpassed varieties in common use in yield and stiffness of stalk. A new double cross, Minhybrid 403, was aprpoved for release in 1937.

The Iowa Station has estimated that the hybrid seed corn crop of Iowa in 1937 would exceed 500,000 bushels. The station's annual corn yield test, in cooperation with the Department of Agriculture (B. P. I.), and a growers' association, was featured in 1936 by the superior performance of hybrid combinations as compared with open-pollinated varieties, hybrid entries averaging 30.8 percent greater in yield than open-pollinated strains. Hybrid entries also were superior in lodging resistance. The lowest yielding strain of all classes of entries in several fields was a regular hybrid, demonstrating that not all hybrids are good, and that the purchaser should buy only known hybrids of proved worth.

The corn performance tests continued in many localities by the Illinois Station also compare numerous varieties and hybrids. In 1936 the best hybrids again were superior to the best open-pollinated varieties in all sections. The five best hybrids in four sections of Illinois outyielded the five best open-pollinated corns by 15.7 bushels of sound corn per acre, or over 46 percent. In silage tests the best hybrid entries surpassed open-pollinated entries in total yield of silage as well as in grain fraction or feeding value. Certain of the better hybrids were favored by a good soil more than were open-pollinated varieties. Several corn varieties and hybrids were shown to have marked resistance to the southern corn rootworm.

Varieties for silage.—The corns excelling in grain production often are not found best for ensiling. The New Jersey Station has developed or introduced certain varieties, such as Mercer White Cap and Lancaster Surecrop, which appear to have distinct advantage over varieties commonly grown for silage. The station believes that farmers have been misled as to the value of tall, late-growing "silage" varieties which produce a heavy tonnage of green material but are considerably deficient in actual feed supply. From comparisons of

varieties suitable for silage, the Rhode Island Station concludes that the choice of a medium maturing corn would seem to be good practice, since it should provide as much feeding value per acre as possible without the handling of too much water in green material.

Seed corn.—Growers are occasionally confronted with a serious seed-corn shortage, such as prevailed in the spring of 1937, and must use seed of various qualities and sources. The Nebraska Station finds new seed corn preferable to old seed, although seed up to 4 years old, when well preserved and of strong germination, has proved satisfactory. Small but sound ears and kernels, stunted by drought, can be used as seed. In years of late maturity, seed corn may be harvested 1 or 2 weeks before fully ripe without impairing seed value if properly cured. Home-grown seed of recognized established varieties should be given first choice, although suitable seed may be introduced from a distance. In general, within a locality in Nebraska, seed corn may be interchanged without respect to soil fertility level. Irrigated seed corn from central and western Nebraska may be moved some distance to dry land east or south but may prove too large and late for dry land in the same locality. In contrast with open pollinated varieties, the adaptation of any specific corn hybrid is said to be unaffected by locality or condition under which the seed is produced, depending entirely upon the component inbred lines.

Spacing of corn.—The merits of normal and double-width corn rows is a recurring subject of inquiry especially under dry-land conditions. The Colorado Station and the Department of Agriculture (B. P. I.), cooperating, found that the total production of ear corn, and of grain from the following wheat crop, was greatest on land where corn was spaced 24 inches apart in 44-inch rows, recommended for grain production, and the highest total weights of corn and wheat (grain, stover, and straw) were obtained from land with 12-inch spaced corn in 44-inch rows. From 12 to 18 inches in 44-inch rows is advised for silage production. The highest average grain yield of winter wheat made on double-spaced row corn land did not more than compensate for the loss in corn.

Drought-injured corn.—Severely drought-injured corn, the Iowa Station found, had the same ratio of leaves to stalks as did normal plants but weighed only 37 percent as much as the stover of normal plants and 10 percent as much as the fodder. Failure to form starch in the vegetative organs makes drought-injured or barren stalks poor substitutes for normal bearing plants. The rapid losses of sugars from plants left standing in the field or air-dried slowly suggested that drought-injured corn would make better feed if cut while still green and dried rapidly, perhaps mowed and dried in the swath, and then ensiled or handled as hay.

Popcorn improvement.—Popcorn is grown widely for local use, but large market production has long been concentrated in two Iowa counties and in a few areas in Nebraska and Kansas. Droughts and short crops in this region have stimulated popcorn growing elsewhere in recent years. Popability, the quality most desired in popcorn, is measured by comparing the popped and unpopped volumes of the kernels. The Department of Agriculture (B. P. I.) and several stations have found that tenderness, but not heavy yield, usually is associated with high popability. In general, methods for breeding

popcorn are about the same as for field corn. By mass selection and tests of individual ears the Kansas Station and the Department raised the average popability of a seed stock from 19 to 26 volumes in 6 years. The Minnesota Station has developed Minhybrid 250, highly desirable in central Minnesota, and is testing another hybrid for farther south. Improved hybrid strains are also promised from work under way at the Iowa, Kansas, Michigan, and Texas Stations.

WHEAT

Improvement.—A number of promising new varieties of wheat are completing the rigid tests necessary before distribution to growers, and recently released strains are beginning to replace older and inferior wheats. For example, Hymar wheat, developed by the Washington Station in cooperation with the Department of Agriculture (B. P. I.) and described as outstanding in winter hardiness, yield, and stiffness of straw, and first distributed in 1935, was reported as replacing other varieties in eastern Washington. Ramona, an early maturing white wheat (Hard Federation × Bunyip), developed by the California Station, has given excellent yields in all that State's wheat-growing sections. Tests of a 6-ton lot of this wheat by a large milling concern revealed excellent quality. Yorkwin, a white wheat developed by the New York (Cornell) Station, is recommended because of its value for pastry flour, resistance to loose smut, and better yield than Honor, which it is designed to replace. Thorne wheat, a new red-kerneled, hardy winter variety, which originated in a cross between Portage and Fulcaster, has been released by the Ohio Station to growers. On the average it has outyielded Trumbull and Fulhio, varieties hitherto making up most of the Ohio wheat acreage.

Disease-, insect-, and drought-resistant wheats.—Brill, a hard red winter wheat, selected from Turkey by the Illinois Station, has shown high yields and unusual resistance to scab, and is a very good bread wheat, considered to have enough good qualities to merit commercial production.

Productive strains of spring wheat highly resistant to black stem rust and in a measure to leaf rust and to heat and drought, and outyielding common varieties, have been developed by hybridization by the South Dakota Station. The Washington Station reports progress in developing promising strains of spring wheat as regards yield, resistance to smut, stiffness of straw, and nonshattering properties especially suited for combine harvesting and one providing greater smut resistance. The Kansas Station has produced a cross of Oro × Tenmarq wheat which is resistant to common physiologic races of smut occurring in Kansas, and also has desirable agronomic characters.

The Oregon Station, cooperating with the Department of Agriculture (B. P. I.), found a few varieties of hard red winter and soft red winter wheat highly resistant to composites of various strains of bunt occurring in the Pacific Northwest. Even though they were highly resistant in these tests, most of the varieties have been found to be susceptible to some races in other tests. Hussar × Hohenheimer, C. I. 10068–1, however, has never shown more than a trace of smut in any test reported thus far.

Recent success by the Illinois Station, cooperating with the California, Indiana, Kansas, and Missouri Stations and the Department of Agriculture (B. E. & P. Q. and B. P. I.), in developing wheat varieties resistant to hessian fly, indicates that such varieties may aid in coping with the pest.

Heat and cold resistance.—Recurring droughts and also losses due to severe winter injury have stimulated much research into factors involved in resistance to injury from these causes. A marked diurnal cycle of heat resistance in wheat and other crop plants was discovered by the Kansas Station. Resistance was high during the afternoon and lower at night, light probably being the main causal factor of increased resistance. The gain in resistance upon exposure to light following darkness was more rapid than the loss of resistance in plants exposed to darkness after several hours in light.

Studying resistance to artificial drought and rate of water loss in wheat, the Department of Agriculture (B. P. I.), cooperating with the Arizona Station, determined the varietal ranking as to decreasing resistance to water loss to be Kubanka, Baart, Ceres, Onas, Marquis, Huston, Hope-Ceres, and Hope, an order similar to that established in greenhouse-grown material.

Winter wheat seedlings showed significant cold-hardiness differences within the same varieties when different seed sources were compared by the Nebraska Station cooperating with the Department of Agriculture (B. P. I.). Post-maturity factors, as sprouting, weathering, or severe mechanical injury, also gave significant differences in hardiness, but seed size and protein content did not. In studying bound water and electrical conductivity as measures of cold resistance, the Illinois Station observed that the crown tissue of winter wheat varieties should receive more consideration than leaf tissue in such tests.

That varieties of winter cereals may differ in the rate at which cold-hardiness is lost in the winter-spring transition from dormancy to the active stage of growth, was suggested by a Kansas Station study. Since considerable winter-killing occurs in early spring when temperatures are only moderately low, wheat and other fall-sown cereals evidently should be spring-hardy as well as winter-hardy. Cold resistance was usually lost more rapidly in varieties possessing the greater midwinter hardiness, yet the contrary also was found. Harvest Queen wheat lost resistance to cold more slowly than Minturki, Kanred, Quivira, Turkey, and Blackhull wheat, and thus retained a relatively high degree of resistance in the spring growth stage.

Cultural practices.—Economical and productive cultural practices continued as objectives of many stations. The Ohio Station, consolidating results of numerous tests, indicates the essentials for production of superior soft red winter wheat to include a good variety such as Trumbull, Fulhio, and Gladden; clean seed treated for seedborne diseases; adequate seedbed preparation and a reasonable fertility level; and planting on or as soon after the hessian fly-free date as possible.

Cultural practices reported by the Wyoming Station as resulting in high winter wheat yields on dry land in northeastern Wyoming, included furrow drilling September 15 at the rate of 30 to 45 pounds

of seed per acre on summer fallow prepared May 1. The best and most profitable yields in rotations were made on fallow. Growing wheat under irrigation at Burns, above 4,000 feet in altitude, the Oregon Station found 96 pounds an optimum seeding rate; less seed could not control weeds on foul ground.

Stabilized wheat production and soil fertility.—Either failure or overproduction of a given crop, the Illinois Station observes, may cause great inconvenience and loss to farmers. Effects of soil treatment in stabilizing yields of winter wheat were seen in yield data from 15 years' work on 18 soil-erperiment fields in Illinois. Fertile, well-drained soils produced high average yields with a high degree of regularity from year to year, while untreated infertile soils were very irregular in wheat production. Poor or intermediate soils studied, except sandy land and hilly land, showed great improvement in stability of wheat production when maintained at a fairly high production level. Although occasional wheat failures or near failures occurred even on productive soils and under approved farming methods, good farming was rewarded by higher wheat yields as well as by fewer seasons of crop failure.

Wheat, after soybeans cut and removed for hay, in New Jersey Station experiments, averaged 25 bushels per acre as compared with 28.9 bushels where the soybeans were plowed under. The latter practice supplemented by sodium nitrate top dressing gave litttle yield increase. However, nearly 8 bushels more wheat was made when sodium nitrate was applied after soybeans removed for hay. Top dressing wheat with nitrogen in the spring on lighter soils, as recommended by the Delaware Station, is being adopted in practice.

Quality.—The quality and strength of wheat varieties, and methods for their evaluation were under study at the Nebraska, Kansas, Ohio, Minnesota, Indiana, and other stations. The outstanding importance of protein content upon strength of soft-wheat flour was shown clearly by the Ohio Station, which observed that amount of protein determined by usual methods probably is the most important single test that is both accurate and rapid. Viscosity measurements also seemed promising as a possible criterion of protein quality. As strength measures, loaf volume and viscosity based on 20 grams of flour proved more accurate and sensitive than time as determined upon wheat meal. Results of tests by the Indiana Station of soft winter wheat varieties from several crops and localities demonstrated that the wheat meal fermentation time test may be a reliable guide in measuring relative gluten quality of soft red winter wheat.

The sulphur content of 21 wheat varieties grown by the Utah Station on a typical deep dry-farm soil, rich in sulphur, averaged 0.18 percent, with a range of from 0.15 in Newturk to 0.22 percent in Hard Federation. Cultural methods tending to improve soil productivity only slightly increased sulphur content of wheat. The total sulphur and total nitrogen of the wheat were closely related.

Wheat malt, prepared from different varieties and types of wheat, was found by the Minnesota Station to vary considerably in capacity to induce sugar production when added to low diastatic wheat flour. The conditions affecting the enzyme action were studied and explained by the station.

See also page 140.

OATS

Improved varieties.—Among new and promising varieties of oats developed in the course of breeding research at the stations, usually in cooperation with the Department of Agriculture (B. P. I.), are Rusota, a white early midseason oats resistant to stem rust and especially suited to northeastern North Dakota conditions, developed and distributed by the North Dakota Station; New Nortex, outyielding Nortex, a sister selection, by about 4 bushels, developed and distributed by the Texas Station; a new winter oats of especial hardiness and high yielding capacity developed and distributed by the Tennessee Station; and a selection from Markton oats which has stiffer straw and broader leaves and also the smut immunity and high yield of Markton, isolated by the Washington Station. Many selections from varieties and crosses made by the Florida Station have shown high resistance to crown rust compared with certain commercial oats most generally planted. Substantial progress in the development of hardier types of winter oats resistant to smut and crown rust was being made by the Department of Agriculture (B. P. I.), cooperating with the Iowa and Idaho Stations.

Oats production.—In extensive experiments with oats, sometimes in cooperation with the Department of Agriculture (B. P. I.), the North Dakota Station found that early-maturing varieties, as Gopher and Iogold, do best in eastern and southern North Dakota and are preferred for the heavier and more fertile soils. Midseason oats, as Rainbow, Anthony, and Victory, better suited to the lighter soils, are usually grown except in southeastern North Dakota. White Russian is the principal late-maturing variety.

Oats varieties indicated to be of superior quality by the Arkansas Station from extensive tests in cooperation with the Department of Agriculture (B. P. I.) include Custis, Lee, Culbertson, and Turf for northern Arkansas and high elevations, and Appler, Nortex, Ferguson (922), or Hundred Bushel, in the cotton-growing sections, preferably planted in late September or early October. The five best winter oats averaged 55.7 bushels per acre and the five best spring oats, 39.9 bushels.

Delayed harvest.—Yield losses probably may be reduced materially, the Michigan Station observed, if oats are cut and windrowed at the fully ripe (25-percent moisture) stage, and cured in and threshed from the windrows with the combine. Markton oats shattered least of the oats varieties tested but lodged most readily.

BARLEY

Improved varieties.—Barley improvements continued to advance in response to demands for better and more productive brewing and feed barleys and for barleys resistant to various diseases and easier to harvest. Olympia barley, a winter-hardy variety of high-yielding capacity, developed by the Washington Station, proved superior to other winter barleys in many respects. A new barley (S–31–62), being increased by the Texas Station for distribution in 1938, averaged 49.3 bushels per acre compared with 38.7 bushels from the most productive present Texas barleys grown commonly. It also is adapted to both fall and spring plantings while most

winter barley will head only from fall planting. The North Carolina Station has developed a strain of barley apparently resistant to smut and is multiplying it for distribution to growers. The Minnesota Station, cooperating with the Department of Agriculture (B. P. I.), reports satisfactory progress in breeding barley resistant to scab, stem rust, blight, and stripe. The New Jersey Station has secured a number of selections of smooth-awned spring barleys which have outyielded Velvet, the standard type, by 25 percent or more.

Barley production.—From its extensive varietal tests, the Colorado Station recommends Trebi, Colsess, Hannchen, Wisconsin Pedigree No. 38, and Velvet barley for irrigated conditions as at Fort Collins; Trebi and Colsess for high-altitude irrigated districts as at Fort Lewis; and, from studies in cooperation with the Department of Agriculture (B. P. I.), Club Mariout, Flynn, and Vance Smyrna for dry land. The station also has published cultural methods and irrigation practices for growers in the several regions of the State and control measures for barley diseases.

Wisconsin Pedigree No. 38 and Spartan barleys, both smooth-awned, were outstanding in Michigan Station tests. Wisconsin No. 38, the best commercially available barley for malt, also yielded highest, whereas Spartan finds its place as a pearling and feed barley. Spartan excels in its much stiffer straw and as a nurse crop for seedlings of alfalfa, red clover, and other forage crops. Seeding rates producing maximum acre yields in the station's tests covered a rather wide range, being for Glabron and Wisconsin No. 38 barley from 1 to 2.5 bushels, for Michigan-Two-Row from 1.5 to 2.5, and for Spartan from 2 to 3 bushels. The optimum rate of seeding appeared independent of environment.

Delayed harvest.—The Michigan Station has observed that yield losses may probably be reduced materially if barley is cut and windrowed at the fully ripe (25-percent moisture) stage and cured in and threshed from the windrows with the combine. Spartan barley suffered smallest losses from delayed harvest and Oderbrucker the greatest.

RICE

Improvement.—Zenith rice, a new variety developed by the Arkansas Station, yields as much as or slightly more than Early Prolific, has grain of better quality, and mills clear and transparent. The station also reports progress in breeding strains of rice resistant to stem rot (*Leptosphaeria salvinii*), which is responsible for considerable losses in Arkansas both in yield and in milling quality. Short-grain varieties, not grown extensively in the State, have been found less susceptible to stem rot than medium- and long-grain varieties, and early-maturing less than late-maturing varieties. Study of crosses made to obtain suitable medium- and long-grain resistant types revealed that a number of selections from Aikoku × Edith, Edith × Kameji, and Kameji × Blue Rose are relatively resistant to stem rot as well as to leaf spot.

Length of growing period.—Rice varieties tending to have a relatively fixed length of growing period, the Louisiana Station cooperating with the Department of Agriculture (B. P. I.) observed, include

Iola, Fortuna, Rexoro, Early Prolific, Delitus, and Vintula. Such rices are considered desirable for farmers wanting to grow the same variety on a large acreage. Varieties tending to delay heading until a certain time in the fall and thereby greatly lengthening or shortening their growing periods included Caloro, Blue Rose, Wataribune, Acadia, Shoemed, and Honduras, which are desirable for a grower forced to plant his crop late in the spring.

Fertilizer.—Nitrogen added to deflocculated Crowley silt loam, the Louisiana Station found, increased the protein percentage in rice heads and the yield. Relatively large amounts of nitrogen and phosphorus in virgin Crowley soil were associated with a high protein and phosphorus content in the rice and a higher yield. Potassium salts as fertilizer seemed to balance excessive amounts of lime and sulphur in their tendencies to cause production of an abnormal proportion of straw. Rice grown on alkaline soil containing considerable soluble and colloidal silica absorbed unusually large amounts of silica, especially in the straw.

Factors concerned with rice growth and nutrition, such as nutrient elements, soil reaction, and soil structure, have been studied extensively by the Arkansas Station. Yield responses to nitrogen, either as nitrate or ammonium salts, but not to phosphorus and potassium, were obtained on certain rice soils. Toxic effects of manganese and iron in nutrient solutions were decreased by adding nitrogen or calcium compounds. Addition of lime failed to give an increase on nonacid soils, whereas it was found that growth of rice could be increased greatly on nonacid soil by nitrogen fertilizer plus acid treatments.

The control of the soil reaction in such a manner as to regulate the amount of calcium in solution or possibly the relationship between the iron and manganese or both with the calcium and nitrogen appears from the data accumulated to be partially the solution of the rice problem or at least to be valuable leads to other problems with rice fertilization.

SEED FLAX

Flaxseed production.—Growing flax for seed is a new industry in California, especially in the Imperial Valley. Information on flaxseed production in the far Western States, gained largely in cooperative investigations with the California Station and published by the Department of Agriculture, considers varieties, cultural and harvesting practices, and control of flax diseases and insects.

Seed flax in Utah.—Bison flax, because of consistently high seed production, favorable yield of oil, good quality, and high resistance to flax wilt, in tests by the Utah Station cooperating with the Department of Agriculture (B. P. I.) and also the North Dakota Station, was deemed the best variety for Utah conditions. Delay in harvest from August 1 to October 1 resulted in substantial yield increases. Estimates were that on the basis of yield ratios in bushels the flax grower must receive 3 times the price per bushel of wheat, 4.5 the price per bushel of barley, and 5 times the price per bushel of oats, for equal gross returns.

POTATOES

Improvement.—Since problems and objectives in potato breeding often cut across State lines and involve large regions of the entire coun-

try, potato improvement has been organized as a national project with all interested State stations and the Department of Agriculture cooperating. Practical accomplishments of the breeding program include the distribution within the last 5 years of several outstanding new varieties of potatoes, such as Warba and Red Warba, Katahdin, Chippewa, Golden, and Houma.

The Houma potato, derived from Charles Downing × Katahdin, was shown in cooperative studies by the Louisiana and other stations and the Department to be a vigorous-growing, late-maturing variety that produces smooth, nearly round tubers, slightly flattened at the apex, with shallow eyes, dark buff in color, and high in cooking quality; compares favorably in total yield with Katahdin, Chippewa, Irish Cobbler, and Green Mountain; and is well adapted to Maine, North Carolina, and particularly to Louisiana.

The North Carolina Station in similar cooperation has made substantial progress in developing earlier strains of potatoes, of higher quality and more resistant to diseases, and in general, better suited to culture in the South. The Maine Station has succeeded in greatly reducing *Rhizoctonia* and in increasing potato yields by persistently selecting Irish Cobbler stock free from the disease. Promising potatoes being developed by the Michigan Station include red- and white-skinned, early productive, drought-resistant, disease-immune varieties with oval tubers free from hollow heart. The red tuber grows best on lowlands. In trials of potato varieties and crosses by the Florida Station some were found to be immune to brown rot (*Bacterium solanacearum*), and certain crosses yielded about twice as much as the variety commonly grown.

Progress also has been reported recently by the Maine Station in breeding potatoes for resistance to late blight and to virus diseases, and by the Minnesota Station for resistance to scab, all in cooperation with the Department of Agriculture (B. P. I.).

Seed potatoes.—Differences in time of maturity and productiveness of seed potatoes of same variety from different localities, the Louisiana Station finds, are due to the time the seed tubers were harvested as well as to growth environment. Such differences are in addition to influence of storage conditions which may hasten or retard the harvest period. Seed from early harvested areas naturally germinate and mature faster than those from areas harvested later.

The Wisconsin Station found that seed potatoes grown on peat land tend to produce heavier crops than those on other soil types.

From seed-treatment studies involving several varieties, the Maryland Station reported that good commercial possibilities exist with the Warba variety in the production of a late crop in Maryland from spring-grown seed treated by soaking cut tubers for 1 hour in a solution of sodium thiocyanate (1 pound to 12 gallons of water) just before planting.

Storage of seed.—Effects of different methods of storing Irish Cobbler and Smooth Rural seed potatoes on subsequent growth and yield have been studied by the New York (Cornell) Station. Conclusions were that in localities where early planting usually results in highest yields it would be desirable to store seed at the higher temperatures to secure sprout growth at planting as large as possible without liability of damage during cutting and planting. Where

later plantings usually result in highest yields, treatment suppressing sprout growth, such as low temperatures, will result in increased yields unless planting be delayed too long. Highest yields of Irish Cobblers usually were obtained after storage at 40° F. for all or part of the storage period, whereas Smooth Rural produced best following 50° for part or all of storage.

The Louisiana Station found that the rest period of fall-grown potatoes could be broken by storage under temperatures ranging from 75° to 80° F. from 2 weeks after harvest until planting time. Seed handled in this way has given yields comparable to those from northern-grown seed.

Growers of Triumph and similar potato varieties are confronted with the problem of holding tubers with minimum loss of weight until shipment, to deliver stock that will grow promptly when planted in the South in January and February, and to hold potatoes for their own planting until about June 15. The Nebraska Station found that, with sound tubers, placing potatoes in cold storage about the time cellars begin to warm up or about when buds begin to elongate into sprouts (in April), was the most desirable and economical of all methods used; with this method losses due to sprout growth and decay were not serious, and the percentage of sound tubers and the yields were about the same as with longer cold storage. Cold storage from harvest to planting resulted in less weight loss and in a higher percentage of sound potatoes than did cellar storage, and with late-June planting stands and total yields were better from cold-stored potatoes. Potatoes stored in sacks lost less weight in fall and winter but more in spring than those in crates, and had more sprout growth and rot. With immature or mechanically injured tubers storage losses were greater than with sound potatoes stored under the same conditions. The least loss occurred when cut tubers were brought promptly into a very damp cellar, a condition conducive to best wound healing.

An earth cellar excavated to about 6 feet below ground level has been used successfully by the Idaho Station and growers for potato storage.

Cultivation.—The New York (Cornell) Station finds that deep cultivation of potatoes is certain to be injurious after the roots have developed in the zone reached by the cultivator. From all viewpoints, the furrow-planting shallow-covering method of culture seems most desirable under New York conditions. It hastens come-up, thereby lessening ravages of *Rhizoctonia*, and permits marked reduction in cultivation costs through use of a weeder until plants are from 8 to 10 inches high, and the cooler, moister soil in level culture tends to produce higher yields, and may not favor scab development. Ridging where necessary should be moderate, completed early in the life of the plant, and remain undisturbed thereafter. Cultivation for either type of culture should be shallow, only for weed control, and should cease at or before blossoming, which coincides with tuber setting.

Potatoes on dry land.—In the High Plains section of western Nebraska, the Nebraska Station found that potatoes have produced very satisfactory yields with only the moisture stored in the soil prior to the emergence of the plants. Best potato yields have been after summer fallow. In years of low rainfall potatoes have practically

failed when planted after small grain, because of serious depletion of soil moisture as deep as the fifth foot, whereas yields after corn have been fairly good since corn removed but little moisture below the third foot.

No distinct differences in nutritive value, including that of vitamin C, could be found by the Wyoming Station between dry-land and irrigated potatoes grown in the State, nor were differences evident in contents of calcium, phosphorus, iron, or magnesium. Varietal differences in composition, i. e., between Bliss Triumph and Irish Cobbler, were greater than differences in the same varieties produced with and without irrigation.

Soil aeration.—That potatoes respond markedly to better aeration of subsoil has been observed by the Ohio Station. Potatoes have practically failed on a good silt loam excellent for wheat and corn unless special measures were taken to keep the soil loose and porous. Air has been supplied by shallow tile lines, by adding sand, and in more practical ways by mixing chopped straw or chopped corn stover into the soil or by plowing down large crops of corn and rye. Addition of decomposed organic matter, lime, or phosphates to the subsoil distinctly increased root development.

Effect of soil reaction.—Studying the effect of varying degrees of soil reactions on Smooth Rural potatoes, the New York (Cornell) Station found that reactions more acid than pH 4.8 reduced the number of potatoes per plant and yields. Plants on the most alkaline soils produced smaller and fewer No. 1 potatoes than did those on less alkaline or on acid soils. The percentage of scabby tubers gradually rose with increase of alkalinity of the soils.

After several years' experiments, the Virginia Truck Station recommends light liming for potatoes, not over 1,000 pounds per acre, of soils showing a reaction of pH 5 during the growing season to avoid overliming and increase of scab. Finely processed limes have produced greatest returns and frequent light applications have surpassed fewer but heavier ones. The Department of Agriculture (B. P. I.) cooperating with this station in soil studies concluded that potatoes may be grown successfully on land flooded with salt water if the salt content is below 1,000 parts per million (0.1 percent) at time of planting and normal rainfall occurs throughout the season. Reclamation methods are suggested.

Fertilizers.—The Montana Station found that different fertilizers for potatoes applied at planting time effect responses at different periods during plant development. Phosphorus responses are immediate, resulting in early plant development and early maturity. Potash response is delayed to late in the season, resulting in late growth and delayed maturity. Nitrogen response is earlier than potash response but continues on to late growth, with late maturity. The definite relation between nitrogen and phosphorus nutrition in the potato plant resulted in the better utilization of each nutrient.

In its Hood River Valley experiments with potatoes, the Oregon Station found nitrogen fertilizers, with or without potassium, and also with sulphur, to be more effective than carriers of a single nutrient element which failed to produce economical yield increases over unfertilized land. The greater tonnage of U. S. No. 1 potatoes from fertilized areas was due primarily to heavier yields, and the

highest average percentage of No. 1 grade was associated with a relatively wide or intermediate nitrogen : phosphorus ratio. The heaviest yields of potatoes followed sweetclover, alfalfa, Hubam sweetclover, vetch, or alsike green manures, while lowest yields came after red clover.

Since addition of copper, manganese, and zinc sulphates singly or in a mixture of all three to potato fertilizers by the Virginia Truck Station failed to result in significant yield increases, the practice is considered currently inadvisable for potatoes in Tidewater Virginia. Marked increases in potato yields following application of manganese sulphate on farms in the Charleston truck area have been obtained by the South Carolina Station in cooperation with the Department of Agriculture (B. P. I.). Recent indications are that the content of certain minor plant nutrients rather than form of nitrogen accounts for the larger yields resulting from the use of organic materials.

The Wisconsin Station among others has found blackening of cooked potatoes to be associated in part with deficiency of potassium in the soil. When the soil contained less than 200 pounds of available potash per acre, several varieties grown thereon blackened after cooking. Blackening was very common in tubers containing less than 1.8 percent of potash in the dry matter, an amount below average for normal tubers.

SWEETPOTATOES

Sweetpotato production.—Information regarding the production, storage, grading, and marketing of sweetpotatoes has been provided for growers by the Louisiana Station. Practices indicated from its experiments include choice of the Porto Rico variety, treatment of selected seed with corrosive sublimate solution before bedding, bedding in rows in the open for the main crop in south Louisiana, and using vine cuttings when beds are in field rows. Spacings and fertilizers also are suggested. Sweetpotatoes should be harvested before frost, usually best in October, the grower avoiding bruising, carefully grading marketable roots, and placing them in storage crates. In curing, sweetpotatoes should be kept at from 80° to 85° F. for from 10 to 20 days just after digging and at from 50° to 60° after curing. In south Louisiana, artificial heat is not needed for roots harvested in October.

The Mississippi Station recently compiled and published results of experiments by stations and the Department in harvesting, curing, marketing, and feeding sweetpotatoes. At Laurel, it was found that roots carefully handled, i. e., placed directly into crates lined with cotton outing cloth, lost less weight in storage with less storage rots, and were more efficient plant producers than roots commercially handled, i. e., thrown into unlined crates.

TOBACCO

Flue-cured tobacco.—From a study of farm practices, the Virginia Station concluded that a large percentage of flue-cured tobacco is being grown on land not adapted to the crop. It recommends that in the case of severe erosion the production of flue-cured tobacco be discontinued entirely and the farm devoted to a soil-improving crop rotation or the land, if too poor, be abandoned altogether.

Cooperating with the Department (B. P. I. and B. A. Eng.), the Georgia Coastal Plain Station has found that the position of fertilizer in the soil relative to the tobacco root system influences considerably the plant's ability to survive transplanting and begin field growth. Placement of fertilizers on the sides of the row was but slightly superior to drilling in the row and thoroughly mixing with considerable soil near the root system. Both methods are deemed satisfactory, yet the latter is recommended until suitable machines are available. Additional cooperative experiments indicated that the optimum amount of potash that can profitably be used on flue-cured tobacco is considerably more than is currently recommended. All factors considered, the station believes that from 8 to 12 percent of potash may be used safely in fertilizers which are applied at the rate of 1,000 pounds per acre.

Cigar tobacco.—Among other findings obtained at Windsor with Havana cigar leaf, the Connecticut (State) Station reports that a single organic nitrogen carrier is as good as several in a fertilizer mixture, although some of the cheaper sources may replace expensive ones; that soybean meal, as a nitrogen carrier, produces tobacco of excellent quality, surpassing cottonseed meal; that the quantity of magnesia in the fertilizer does not greatly affect yield or grading but decidedly influences combustion, an annual application of from 75 to 100 pounds of magnesian lime (which resulted in about 2 percent of MgO in the leaf) being preferable to larger applications at intervals of several years; and that a formula including cottonhull ashes and cottonseed meal has produced excellent tobacco. Cooperative experiments demonstrated that Broadleaf growers could safely use results from fertilizer tests with Havana tobacco at Windsor as a basis for practice.

Irrigation, the station observed, could be used on a droughty, easily leached light sandy soil with promising results, if nitrate also be supplied. That practice might also be followed to a certain extent on heavier soils. Indications were that the grower would profit greatly by leaving Havana Seed tobacco in the field for at least 3 weeks after topping, except when confronted with danger of plant starvation on account of excessive rainfall, too little fertilizer, or a soil not retentive enough.

Its study of fertilizer requirements of cigar-leaf tobacco leads the Pennsylvania Station to recommend that 1,000 pounds per acre of a 3–5–12 mixture be used with about 10 tons of manure.

SUGAR CROPS

Sugar beet seed.—The sugar beet seed industry, a recent enterprise in New Mexico, covered 1,942 acres in 1936 and produced about 1,874,000 pounds of seed with a farm value of about $140,000, largely the direct application of results of experiments by the New Mexico Station cooperating with the Department of Agriculture (B. P. I.). The industry has expanded into other States with similar conditions for growing the crop. Preferred practices include the choice of medium to heavy loam soil; planting early in September at an 18-pound-per-acre rate drilled in 22-inch rows, unthinned; and fall irrigation enough to establish stands and spring irrigation every 2

weeks from start of growth until blooming and weekly thereafter. Manure at the rate of 10 tons or more per acre gave especially good results, and early spring application of nitrogenous fertilizer, as ammonium sulphate, to supply from 40 to 50 pounds of nitrogen per acre proved very profitable.

Periods and weather conditions found by the Michigan Station cooperating with the Department of Agriculture (B. P. I.) to be most favorable to a high percentage of beets with seed stalks comprised a cool, wet, cloudy May 16–31, with similar weather extending into the last half of June; and most favorable to a high seed yield were the same periods and conditions especially favoring seed stalk development and a cool, dry July 1–15.

Tillage and irrigation of sugar beets.—The California Station found no difference in the yield, shape, and sugar content of sugar beets, whether the land was plowed or only stirred to provide enough loose soil to cover the seed and to remove weeds. These observations harmonize with other results showing that plowing and deep tillage usually are unnecessary orchard practices. Irrigation studies revealed that wide fluctuations in soil-moisture conditions do not affect the sugar content. The increase of sugar in the roots, apparent when beets are subjected to prolonged drought, probably results from translocation from the leaves while the plants are wilted.

Drought-resistant sugarcane.—The fact that despite the drought in 1936 Louisiana sugarcane growers harvested one of the best crops in years is attributed to the increased use, about 83 percent of the 1936 crop, of disease- and drought-resistant varieties developed by the Department of Agriculture (B. P. I.) at Canal Point, Fla., and tested for many years by the Louisiana Station. The new canes, C. P. 28–11, C. P. 28–19, and C. P. 29–320, mature earlier than older canes in common use and produce high yields and sugar content in the second and third years.

SORGHUM

Hybrid vigor in sorghum.—In tests of an extensive series of hybrids between different types and varieties of sorghum, the Texas Station observed that some phenomenal yields were due to heterosis in the first hybrid generation. An F_1 hybrid of feterita and hegari, for example, produced a yield of 126 bushels of grain per acre, about two and one-half times as much as the higher-yielding parent. The possibility of using this phenomenon commercially in producing hybrid seed is suggested by discovery of two types of male sterility which are inherited as simple recessives. By introducing these into well-known varieties by the usual methods, hybrid sorghum seed should be produced almost as easily as hybrid corn seed is now being produced in many States.

Disease-resistant sorghums.—Early Kalo, an early-maturing, productive selection from Kalo, developed by the Kansas Station in cooperation with the Department (B. P. I.) and proved to be well adapted to conditions in northern Kansas and as far north as North Platte, Nebr., is resistant to milo disease, although susceptible to chinch bug injury. Double Dwarf Darlo, the California Station reports, has shown a high degree of resistance to root rot, which has threatened the destruction of the milo crop.

By crossing Sudan grass with Leoti sorgo, the Texas Station has obtained sweet-stalk hybrids resistant to red spot and with distinctive color of seeds. Quadroon (three-fourths yellow milo and one-fourth Blackhull kafir), a new Texas Station grain sorghum, has matured earlier than milo, is drought-resistant, well adapted to combine harvesting, and has made good yields.

Varieties.—The value of sorghum as a supplement for corn in average seasons and as a good substitute in dry years was demonstrated by the Arkansas Station. Its extensive variety trials showed Schrock leading the grain sorghums and followed by shallu, milo, and darso in grain yield, but no one variety led consistently in forage production. No adverse effects on crops succeeding sorghum appeared in the rotation, sorghum, soybeans or cowpeas, and oats or wheat in which clover was sown.

Sagrain.—Experiments by the Mississippi Station showed Sagrain, a selected strain of Schrock sorghum, to be well suited to the Yazoo-Mississippi Delta. Sagrain has produced more grain than ordinary sorghum and has proved to be a safer feed crop than corn. It has responded readily to fertile soils, fertilizers, and good cultivation, and withstands adverse conditions better than other feed crops of the area. The station has published directions for its culture.

Irrigation requirements.—In irrigation experiments with grain sorghum (hegari), the Texas Station demonstrated that about 38 to 39 inches of water would be optimum under conditions in the Wichita Valley. The total amount of water required for maximum yield appeared to be influenced by seasonal conditions, including amount and distribution of rainfall, humidity, and temperature.

Germination of seed.—Germination increased considerably in June 15 plantings as compared with earlier plantings due to more favorable soil temperatures in cooperative studies by the Kansas Station and the Department of Agriculture (B. P. I.). Germination was usually highest for sorgos and darso and lowest for certain soft-seeded grain sorghums, including feterita, Club, and hegari. Better stands usually were obtained with the harder seeded varieties having a thin mesocarp than with feterita. Delayed harvest and exposure to frost and sleet greatly reduced germination.

Sorghum to prevent soil blowing.—Consideration of new crops for the dry Great Plains region led the Kansas Station to conclude that if profitable industrial uses could be found for part of the potential production of grain sorghum in that region it would aid in bringing into more rapid use those practices essential for the control of soil blowing and stabilization of the agriculture of the southern Plains States. Furthermore, such use of a part of the product would reduce the inevitable competition of grain sorghums with corn on the central markets as sorghum production increases.

SOYBEANS

The continued extension of soybean production in the United States, rapidly approaching the status of a major crop, has been evident in the research programs of the several stations. A survey by this Office revealed that the active station projects concerned with various phases of soybean research, including a number in cooperation with the Department of Agriculture (B. P. I.) and with the

United States Regional Soybean Industrial Products Laboratory at Urbana, Ill., totaled 245 projects in 1937, an increase of 30 over 1936.

Soybean production.—From a study of production practices and costs in growing soybeans on Illinois farms and the crop's place in farming systems, the Illinois Station finds that production has increased rapidly and shows that soybeans have served well to replace winter-killed wheat and to supply hay in years when other forage crops were short. The rapid increase in acreage, 1925–35, indicated that soybeans have largely passed through the crop-adjustment stage, although the wide variation from farm to farm in costs and in growing and harvesting practices indicated that the adjustment process is neither complete nor uniform.

Production of soybeans is still uncertain or in the experimental stage in a number of States. Results obtained by the New York (Cornell) Station in growing soybeans for hay, silage, and grain indicated that the crop's place in northeastern agriculture is not entirely clear but is promising enough to justify additional studies and further quest for more and better varieties suitable for the conditions. The Montana Station's results have not been favorable for soybean seed or hay production in that State on either dry or irrigated land, alfalfa and annual cereal grains producing more hay per acre. The station recommends that soybeans be planted only in areas where adapted varieties of dent corn mature normally, using certain early varieties for seed and for hay. Cultural methods similar to those for corn and field beans are indicated. The Michigan, New Jersey, and North Carolina and other stations have also summarized the results of their research and experience in growing and utilizing soybeans in publications of practical information.

In its prolonged comparison of soybean varieties for hay, seed, and oil, the Arkansas Station found that certain standard varieties such as Chiquita, Laredo, and Mammoth Brown were often equaled or surpassed by newer varieties, selections, and hybrids. Oil content ranged from 13 to 23 percent with most varieties, about 18 percent being the average. The Illinois Station has found four desirable varieties of soybeans which provide green-shell beans from late August to early October, thus increasing variety in late summer or early fall vegetables. In the station's test of nearly 470 varieties for food, only 6 were rated as very good and 70 as good.

Effects on following crops.—The Illinois Station finds that soybeans leave the soil in a loose or friable condition and thus subject to erosion. Furthermore, the crop not only removes large amounts of mineral elements from the soil but draws upon the supply of these nutrients until late in the growing season. Consequently, fall-seeded crops following soybeans frequently need fertilization. Harvesting the seed crop with a combine seemed less detrimental in this regard than removal of the hay. The station determined that much better yields of soybean hay may be obtained by delaying harvest until the seed is developed to one-half full size or larger and also that hay harvested at this stage has a higher feeding value than hay cut early.

Nodulation.—Effective strains of the nodule organism studied at the Wisconsin Station produced relatively few large nodules on Manchu soybeans, most of which were on or close to the taproot near

the soil surface. An ineffective strain set many small nodules scattered over the entire root system, although it produced a greater number, volume, and weight of nodules on each plant than the effective strains.

Soybean nodule bacteria were not harmed when ammonium sulphate in increasing amounts up to 600 pounds per acre was applied by the Mississippi Station to limed and unlimed Lufkin clay growing inoculated and uninoculated soybeans. Soybeans yielded about 50 pounds more hay per acre where ammonium sulphate supplied the nitrogen than where 1 pound of nitrogen was fixed by nodule bacteria.

Quality as affected by maturity.—Soybeans harvested before maturity by the Mississippi Station contained higher percentages of fat, protein, and fiber and lower percentages of nitrogen-free extract than mature beans. Oil of such immature beans had a slightly lower refractive index and a considerably lower iodine number than the oil of mature beans. Comparison of damaged and badly decayed soybeans, the results of harvesting and storage hazards, with sound beans, showed that as decomposition progressed the percentages of fat and protein increased and the percentage of nitrogen-free extract decreased, and the iodine number decreases were considerable. Germination produced similar changes as decay except that iodine number was increased. These findings have practical value in regard to soybeans grown for oil.

ALFALFA

The numerous problems involved in alfalfa production, varieties and their improvement and adaptation, culture, fertilization, maintenance of stands, winter hardiness, and harvesting practices continue to engage the attention of the agronomist and collaborating scientists of the stations throughout the United States and the Department of Agriculture.

Possibilities of combining high yield in alfalfa with a well-branched root system (associated with frost resistance) and with early blooming, were demonstrated by the New Jersey Station, which also observed that soil texture and drainage are important factors in longevity of alfalfa stands in New Jersey and that drainage, available nutrients, and soil reaction significantly affect alfalfa-seed production in the Eastern States.

Foreign strains of alfalfa.—Tests by the Illinois Station on experimental fields located in different parts of the State demonstrated that foreign strains of alfalfa, except those from Canada, are not adapted to Illinois conditions. Planting them results in losses through immediate crop failures and production of inferior hybrid strains caused by cross-pollination with domestic varieties. Foreign strains of alfalfa in general made much poorer stands than domestic alfalfa, and the plants were subject to severer attack by insects and disease and were more easily winter-killed. The same was true for plants of foreign red clover. The real inferiority of the foreign red clover strains, except those from Canada, showed in inability to produce a crop the second year. Procedures other than importation and use of unadapted seed in times of shortage of domestic seed are suggested for Illinois farmers.

The North Dakota Station has found Ladak alfalfa superior to other variegated alfalfas in ability to withstand drought and winter injury under the climatic conditions of Fargo.

Fertilizers.—The Arizona Station finds that alfalfa requires little or no nitrogen fertilizer on alkaline calcareous soils, but responds profitably to phosphate and potassium where these are deficient. Few irrigated Arizona soils appear to lack potassium, but phosphate deficiency is general. The station recommends an initial application of 200 pounds per acre of ammonium phosphate or triple superphosphate followed by an annual application thereafter of 100 or 200 pounds. Phosphatic fertilization has added to the value of hay by appreciably increasing the phosphorus content with a small increase in nitrogen and therefore protein. The Kentucky Station reports that farmers in that State are obtaining high yields of alfalfa hay following applications of lime and triple superphosphate.

The successful growing of alfalfa as a dairy feed in Wisconsin has been made possible by proper soil treatment, as indicated by the rapid soil tests which the Wisconsin Station has made for many years. These have shown that for success with the crop, about 85 percent of the soils of the State need lime, 75 percent need phosphates, and 65 percent need potash.

Borax applied at the rate of 5 pounds per acre in March, the North Carolina Station observed, effectively corrects the yellowing of alfalfa occurring particularly in dry weather with severe infestations with aphids and leafhoppers. Similar treatment in May was without visible effect until the next year.

Cutting alfalfa.—Three cuttings of alfalfa per year, with the last cutting about September 1, resulted in a maximum yield of good-quality hay and maintained a good stand at the Iowa Station. Excellent stands lasted longer with only two cuttings per season than with three, but the yield the first year after seeding was significantly lower. Regardless of the number of cuttings per season, cutting after September 15 seemed inadvisable both as to hay quality and stand.

Studying effects of late-summer and early-fall cutting on crown-bud formation and winter hardiness of alfalfa, the Michigan Station found that, compared with alfalfa plants not cut, or cut in October, plants cut in September developed fewer crown buds, produced fewer stems when active spring growth was resumed, produced a smaller first crop the next year, and were more susceptible to winter injury and severe winter-killing and heaving of plants. Alfalfa cut by the Hawaii Station in the full-bloom stage outyielded that cut in the one-tenth to one-fourth stage, or in the bud stage. In Hawaii, with a year-round growing season, alfalfa to be fed green as a soiling crop probably does best in yield and persistence if cut in the full-bloom stage.

Curing alfalfa hay.—Comparing methods of drying alfalfa hay, the Oregon Station found that from the viewpoint of removing the hay from the field as fast as possible, it is safest to leave the hay in the swath until tough, thus getting the most swath drying and avoiding loss of leaves. If adverse weather is not threatened and a longer time in the field is possible, the alfalfa is best windrowed as soon as wilted. While sun bleaching injures appearance and sal-

ability, it lowers feeding value scarcely at all, and a little is indeed preferable to any rain bleaching.

Seed production.—Temperature rather than relative humidity, the Kansas Station found, is a major factor affecting alfalfa-seed production. The maximum percentage of flowers setting seed pods occurred around 70° F. and the largest average number of seeds per pod was obtained between 75° and 95°. Increase in relative humidity above 15 percent tended to decrease seed-pod formation.

CLOVER AND SWEETCLOVER

Liming legumes.—Small quantities of fine limestone applied in the row with seed on acid Marshall silt loam by the Iowa Station caused depression in the early growth of sweetclover, but on Grundy silt loam no detrimental effect was observed either on alfalfa or sweetclover. Limestone so applied did not depress nodule formation. Limestone also decreased seedling death rates caused by pythiaceous fungi 3.4 percent for alfalfa, 3.7 for sweetclover, and 8.2 percent for red clover.

Ordinary applications of superphosphate alone or with a slight application of lime did not increase the phosphorus percentage in sweetclover at the Kansas Station, nor did light liming increase the calcium percentage. Larger responses in plant growth from phosphorus or calcium tended to be associated with a smaller percentage of the corresponding elements in the plant. Little or no response was noted with increased applications of these elements. Light lime applications tended markedly to reduce the percentages of phosphorus and nitrogen in sweetclover, and the application of superphosphate to produce a lower calcium content.

Sweetclover varieties.—By artificial freezing tests, the Washington Station found the Arctic, Grundy County, Alpha 1, Stone Prolific, and White Madrid sweetclovers to be hardier than Grimm alfalfa. White Madrid withstands weeds best, furnishes most pasture, and is most suitable for the Palouse country because of its early growth in spring and late growth in fall. Arctic, because of its hardiness, is deemed safest for the drier areas of the Big Bend country.

The Wisconsin Station and the Department of Agriculture (B. P. I.) cooperating have found a nonbitter sweetclover (*Melilotus dentata*) which is practically free from coumarin. This has been fed to experimental animals in the form of spoiled hay without ill effects. Both annual and biennial flowering forms are evidently free from the characteristic bitter taste of the white (*M. alba*) and yellow (*M. officinalis*) sweetclovers. A short method has been devised for determining accurately the amount of coumarin in this material.

Lespedezas for milk production.—Early harvested lespedeza hays, the Virginia Station found to be of high feeding value compared with most farm hays, although slightly inferior to alfalfa hay. Korean lespedeza and *Lespedeza sericea* hays, about equal in digestibility and in milk production, have given results equal to 80 percent of those from alfalfa hay. Good leafy grades of the hays were worth about 10 percent more than medium grades. The ideal stage for cutting seems to be in full bloom and before leaf shedding.

OTHER LEGUMES

Improved legumes.—The Macspan peanut, a variety bred by the Texas Station and characterized by high oil content and other desirable qualities, has become the leading popular variety in Texas. It yields 15 percent more than the unimproved Spanish peanut from which it was developed.

Norida, a small white bean, developed by the Idaho Station from a cross between Robust and Great Northern, has been found to outyield Robust and to mature nearly a week earlier. Declining yields of small white beans in the cool coastal valley of California were shown by the California Station to be due largely to scab caused by *Rhizoctonia solani*. Resistant strains of good quality, developed by selection, are being increased for distribution to growers for production of improved seed.

Prolonged efforts by the New Mexico Station to improve the pinto bean, particularly in yield, bushiness and erectness, size and color of bean, and uniformity of marking, have resulted in many promising selections which appear to surpass in many respects the kinds commonly grown. It is expected that a superior strain will be released soon to the farmers of New Mexico.

Field stacking beans.—Providing practical information on methods of field stacking of beans to minimize percentage of pick or culls, the Michigan Station reports that the pick in Michigan beans, 1914–34, averaged 8.16 percent. Such cull beans are caused by disease, insect injury, improper handling, and unfavorable weather. Robust is an excellent variety in respect to pick because of disease resistance and heavy vine growth which tends to keep the pods off the ground. Curing beans in well-constructed field stacks largely eliminates weather hazard at harvest; relieves pressure on other fall work, since the beans can be stacked when pulled and threshed later; and permits the seeding of wheat or rye between the stacks with a minimum of seedbed preparation and without waiting until the beans can be hauled.

Cowpeas as an intercultural crop.—The greatest increase in a crop after cowpeas in corn, according to results by the Arkansas Station with oats and cotton, followed cowpeas planted in the same row and at the same time as the corn. The better cowpeas for hay included Clay, Groit, Iron, Victor, Brabham, Whippoorwill, and Taylor, and for seed production, Holstein, Large Blackeye, Groit, Brown Sugar Crowder, Arlington, and New Era.

GREEN MANURE AND COVER CROPS

Residual effects of legumes.—The New York (Cornell) Station found that cereals (barley and rye) grown in annual alternation with legumes yielded more following alfalfa than after any other legume. Red and alsike clover and sweetclover, about equal in effect, surpassed soybeans, field beans, vetch grown with wheat, and peas with oats in this respect. Cereals after any of the legumes outyielded the same cereals in rotation of cereals only. Alfalfa gave annual cuttings more than twice as large as those of any clover, and soybeans produced much more dry matter than any clover. The superior yield of red and alsike clover in mixture as compared with

either grown singly was noteworthy. The annual legumes were much less effective in influence on the nitrogen contents of succeeding crops than were the perennial or biennal legumes.

Winter green-manure crops.—More general use of winter vetch and crimson clover on cornfields to be cropped to corn the following year seems warranted by New Jersey Station results. Vetch, crimson clover, red clover, and sweetclover in order greatly surpassed rye and wheat in improving yields of the following corn crop. The value of the green manures was correlated closely with the total amount and the percentage of nitrogen contained. Their growth did not appreciably affect the rate of lime depletion or supply of readily available soil phosphorus, and seemed to retard deterioration in soil structure and loss of soil organic matter. Broadcasting in late August, without cultivation to cover the seed, is recommended as an effective and economical method.

Cover crops.—Yields of both corn silage and soybean hay in a 2-year rotation of corn and soybeans on level land at the West Virginia Station were increased by cover crops of rye, rye and vetch, and vetch, but due to severe winters, crimson clover and sweetclover were not satisfactory cover crops. On slopes, beneficial effects of cover crops would undoubtedly be greater due to reduction of erosion losses. The station points out that cover crops alone cannot in any sense replace lime and fertilizer.

In 2-year rotations with different cover crops at the Florida Station, the highest yields of sweetpotatoes were made after *Crotalaria striata*, and of corn after velvetbeans and *C. striata*, and substantially increased yields after Florida pusley or Mexican clover (*Richardsonia scabra*), beggarweed, and cowpeas. *C. striata* made about two and one-half times the top growth made by cowpeas.

GRASSES AND HAY CROPS

Timothy improvement.—Leaves of early and late timothy selections remained green longer than ordinary timothy in cooperative studies by the Ohio Station and the Department of Agriculture (B. P. I.). The higher percentage of protein, greener color, and higher grade of hay produced by the late selection could be attributed to the later dates at which the leaves appeared and to the longer time each leaf remained green compared with ordinary timothy.

Crested wheatgrass.—Crested wheatgrass stands were best obtained by the Montana Station, cooperating with the Department of Agriculture (B. P. I.), by seeding on a relatively firm, moist, weed-free seedbed. This grass can be sown in early spring on a good seedbed, in early fall mainly where fall-sown crops survive and do well, and in late fall on poorly prepared soil such as abandoned land, in stubble, and in old, thin stands of alfalfa. Crested wheatgrass has maintained productive stands for many years, has consistently outyielded bromegrass, and has withstood more extremely unfavorable conditions.

Crested wheatgrass, the New Mexico Station found, is adapted to northern New Mexico and to comparatively high altitudes in the central part, although not suitable for the warmer sections. It has not endured drought so well as blue grama grass but somewhat better than slender wheatgrass. Crested wheatgrass furnishes palatable

feed even a week or 10 days earlier than smooth bromegrass. Shallow planting on plowed land late in June or early in July is suggested.

Small grains and winter legumes for hay.—Rates of 10 or possibly 20 pounds per acre of hairy vetch or 15 pounds of Austrian Winter peas seemed adequate for combination with oats or wheat sown at rate of 60 pounds per acre in Georgia Station studies. The legume content of the hay rose with the rate of seeding Austrian peas or hairy vetch and decreased with the rate of seeding oats or wheat.

Curing forage crops.—Use of the hay crusher, the Pennsylvania Station found, reduces materially the loss from spoiled alfalfa and other forage crops without disadvantages except the current high cost of the machine. Artificial curing or dehydration in a drier was found as a result of the more rapid curing to conserve the carotene (vitamin A) content of hay, and thus to improve its feeding value. Exposure of alfalfa to the sun for a few hours—only long enough to wilt it—reduced the carotene content to a marked degree. Ensiling of alfalfa is considered superior to artificial drying as a means of conserving carotene.

See also page 189.

PASTURES

Interest in pastures continued unabated throughout the United States and was evident in the increased pasture research undertaken and reported on by various stations, many of them cooperating with the Department of Agriculture (B. P. I.). Several stations published practical information on pasture crops, fertilization, and management.

Fertilizers.—The great draft on the mineral plant foods in pasture soils by removal in grazed grasses and by leaching and erosion, resulting in run-down pastures, poor vegetation, etc., has given rise to many fertility studies. The West Virginia Station, studying effects of fertilizers and liming on the calcium and phosphorus contents of pasture herbage on DeKalb and Huntington silt loams, concluded that the herbage from many West Virginia pastures may be inadequate for the phosphorus requirements of the grazing animal, but probably generally contains enough calcium, except possibly in broomsedge and poverty grass pastures that contain only a small percentage of edible weeds. Pastures with a high percentage of Kentucky bluegrass or a combination of bluegrass and white clover will contain sufficient phosphorus in the herbage.

The Pennsylvania Station finds that the carrying capacity of pasture on DeKalb soil can be increased from 100 to 400 percent by fertilizers, especially phosphorus and lime. Clover and droppings of grazing animals supply most of the nitrogen needed. Heavy top dressing with nitrogen carriers is advisable only when a limited acreage is available for intensive grazing, especially in production of high-priced milk.

Cooperative pasture experiments with farmers showed the Ohio Station that investment for superphosphate equivalent to $1.65 an acre per year over 6 years resulted in an average increase of about 950 pounds of dry matter per acre of pasturage, and also improvement in quality of herbage. About 400 pounds of superphosphate

per acre gave best results and the effects endured for several years, maximum increase being secured the third year after treatment. The Virginia Station found the costs of producing food nutrients for cows in the form of pasture to be 36.4 cents per 100 pounds of digestible nutrients on unfertilized pasture, and from 47.7 to 77 cents on land receiving fertilizer and lime. Nitrogen in fertilizer proved expensive since the increase in production obtained cost $1.48 per 100 pounds of digestible food material. In every case it was more profitable to fertilize than to buy hay at current prices.

Improvement and management.—Success in establishing and maintaining good pastures depends on judicious choice of plants, high-quality seed, adequate testing and fertilizing of the soil, a compact seedbed, care in planting, and good judgment in grazing practices, concludes the Illinois Station, which has published practical information on the establishment and management of pastures, and recommended suitable mixtures of grasses and legumes for different purposes and situations in Illinois.

The Michigan Station was successful in developing pastures on cut-over land in the Upper Peninsula by burning over, pasturing with sheep, and seeding with appropriate mixtures.

Pasture improvement and management in the Northeastern States, the New York (Cornell) Station indicates, involves application of needed phosphorus, supplemented by lime and potash on soils which respond to them. The nitrogen required was obtained best by encouragement of pasture legumes, especially wild white clover. Close grazing with short rest periods and use of the mowing machine, flexible grass harrow, and roller were essential for development of the desired turf. The ideal turf for grazing in the region is leafy, extremely dense, about 4 inches high, and contains about 50 percent of wild white clover and other pasture legumes and 50 percent of desirable pasture grasses which grow actively during different periods in the grazing season. Such pastures enable grazing animals to consume daily the maximum amount of total digestible nutrients and provide an adequate supply of minerals and vitamins.

In the rice area of southwestern Louisiana, the Louisiana Station, cooperating with the Department of Agriculture (B. P. I., B. A. I.), found that from 3 to 5 years may be needed to establish fairly good permanent pastures for cattle on ordinary rice land by preparing the soil, fertilizing, seeding recognized pasture plants, and mowing occasionally to control weeds. The pasture may be mowed for hay in summer when there is pasturage for the cattle on the fallow rice lands, or else special areas can be provided for hay.

Renovation, i. e., establishment of dry-weather legumes such as alfalfa, sweetclover, and red clover, in permanent bluegrass pastures without plowing, as practiced by the Wisconsin Station, resulted in very small populations of white grubs (due to egg depositions of June beetles in May and June), and injury was practically eliminated, while grubs usually were plentiful in adjacent unrenovated grass.

Pasture and range plants.—Mixing alfalfa and bromegrass, according to Michigan Station experiments, furnishes productive and drought-resistant pasturage high in palatability and nutrients and valuable not only in summer but throughout most of the grazing season under proper management practices, and is also adapted to a

wide range of conditions in Michigan. Cultural and grazing management practices were recommended.

The Montana Station, cooperating with the Department of Agriculture (B. P. I.) at Moccasin, showed crested wheatgrass and bromegrass pastures to have from 2.5 to 3 times the carrying capacity of native grassland. Permanence and high productive capacity recommend crested wheatgrass for pasture purposes on dry land. It sets seed abundantly both on dry land and under irrigation. By virtue of its hardiness, aggressiveness, and seeding habits, crested wheatgrass is well adapted to growing on much of the abandoned plowed farm land in Montana.

The best pasture plants for the rice section of southwestern Louisiana, the Louisiana Station reports, have included Bermuda and Dallis grasses, common lespedeza, white clover, and California burclover. The most rapid growth was obtained from a mixture of white clover, Bermuda grass, and lespedeza. A mixture of Dallis and Bermuda grasses, white clover, and lespedeza provided pasturage for the longest period in the year.

The Alabama Station reports that kudzu furnished good grazing during July and August when the carrying capacity of permanent pasture was low, 1 acre carrying one cow for about 65 days. Cows on kudzu without supplementary feed made average gains of about 1.25 pounds per head daily.

White clover is particularly desirable as a pasture plant, the Vermont Station finds, being nutritious, improving herbage, distributing pasture yields to good advantage throughout the season, lowering soil temperatures, forming turfs quickly, withstanding droughts, and increasing the organic matter of the surface soil. Its growth is favored by a plentiful supply of minerals, judicious use of nitrogen, small applications of potash, and moderate grazing.

Wheat, oats, rye, barley, and ryegrass, the Texas Station demonstrated, have proved valuable for winter pasture and worthy of planting for grazing value alone, although they (except ryegrass) are also dependable producers of grain. The forage is high in feed value, usually analyzing from 3 to 5 percent of fat, and about 25 percent of protein at the beginning of the season and diminishing as the season advances. Grazing from these small grains becomes available in the fall just as the grazing from Sudan grass is declining and lasts well into the spring when the native-grass pastures are ready. In fact, it usually is possible to change to native-grass pasture from wheat and oats in time to avoid reducing the expected grain yields.

That buffalo grass has wide distribution in Texas and is one of the most satisfactory pasture grasses for much of the State's area was shown by a Texas Station survey. Buffalo grass can withstand drought and heavy grazing. The grass forms an effective turf quickly and is also popular in grassing over eroded areas turned back from cultivation into pasture. The ability of buffalo grass and blue grama to endure heavy grazing, and also drought, has been demonstrated by the Department of Agriculture (B. P. I.) cooperating with the Kansas Station in the Great Plains.

59024—38——4

REGIONAL CROP PRODUCTION

The general crop production of specific regions, as the Great Plains, Cotton Belt, Great Basin, and more limited areas has been given increasing attention by the stations, usually cooperating with the Department of Agriculture.

Dry-land crops.—In 21 years of work under somewhat severe dry-land conditions in the northern Great Plains, the South Dakota Station found the most effective crop sequence has included a cultivated crop, a small grain, and a legume in order. Many modifications of this system are available. The yields of small grains and flax, when worth producing, were made after cultivated sorghum or corn, whereas yields were not worth-while with continuous small grain. Highest yields and returns from staple crops were obtained in short rotations including wheat. Information on the effects of tillage method, crop sequence, and date of seeding upon the yield and quality of cereals and other crops grown under dry-land conditions in north-central Montana, based on prolonged investigations by the Montana Station in cooperation with the Department of Agriculture (B. P. I.), has been published with suggested possibilities of practical application.

Experimenting on dry land in eastern New Mexico in cooperation with the Department of Agriculture (B. P. I.), the New Mexico Station found grain sorghum, sorgo, broomcorn, cowpeas, beans, and peanuts to be the better adapted crops. Crops after pinto beans in rotation have yielded about as much as on fallow. Cowpeas made good yields of excellent hay, and crops after cowpeas outyielded those following sorghums or corn. Fallowing did not increase yields of following crops enough to be economical, and, too, fallow land is subject to blowing. Listing, preceded by early spring cultivation to prevent soil blowing and to kill early weeds, has been practical for row crops. Barnyard manure, but not green manure, has increased yields of succeeding crops. Crop rotation, especially when including cowpeas or beans, has been preferable to continuous planting.

Crops on gumbo soils.—The Missouri Station, cooperating with the Department of Agriculture (B. P. I.), has shown that on the gumbo land in the larger river bottoms of the State, small grains—rice, wheat, oats, barley—alternating with soybeans or lespedeza produce much more total feed per acre than corn and at the same time decrease the need for difficult and expensive tillage, since the soybeans loosen and mellow the soil so effectively that grain can be drilled with little or no additional preparation of the seedbed.

Crops for Black Belt soils.—Corn, peanuts, soybeans, sorghum, and Dallis grass, the Alabama Station found, were more generally suited to all types of soils and appeared to be especially well adapted to Black Belt conditions. Oats and alfalfa produced excellent yields on Sumter clay when properly fertilized, and oats also yielded well on Vaiden clay. Lespedeza produced excellent crops on the acid Vaiden, Eutaw, and Lufkin clays. Because of low yields, cotton is not usually recommended for the Black Belt, especially on the lime soils, i. e., Houston and Sumter clay. Phosphorus, needed on all soil types for most crops tested, should be the most important element of any fertilizer for crops of the Black Belt.

HENRY M. STEECE.

HORTICULTURAL RESEARCH

As evidenced by the reports of research workers published during the year, there were apparent certain changing trends in the field of experimental horticulture, embracing fruits, vegetables, and flowers. There was an obvious trend away from certain of the older types of studies such as those relating to growth and fruiting response, possibly because, in many instances, these investigations had gone about as far as possible due to the complex and ever-changing nature of living tissues.

With the development of new methods in the conserving of fruit and vegetable crops, such as the quick-freezing process, and with the discovery that individual varieties within a species may differ widely in their content of food values, such as vitamins, there has been disclosed a definite need for the creation of new fruits and vegetables that meet specific requirements. Hence there was evident a new impetus in breeding studies at several of the stations.

Among other new and important developments in horticultural research is an increase in the number of studies of the role of certain so-called minor nutrients, such as boron, manganese, and zinc. For example, one finds several papers in the 1936 Proceedings of the American Society for Horticultural Science on the effects of boron in preventing the formation of the so-called internal cork in apple fruits and the internal browning of cauliflower and turnips. The newly discovered growth-promoting substances, such as indoleacetic acid, because of their potent influence on root development of cuttings from species, some of which could not hitherto be rooted, are beginning to influence propagation studies in horticulture. It therefore appears that horticultural research is far from static, but is in an ever-changing condition presenting new problems that require new technic and training on the part of the investigators, all of which tends to promote a maintenance of interest in horticultural research and enhance the possibility of productive effort.

FRUITS AND NUTS

Varietal improvement.—The testing of varieties, often considered as an elementary procedure, has been defended vigorously by the New Jersey Station as a truly scientific problem which, if properly conducted, may require the service of the biochemist, plant breeder, and plant physiologist, as well as the horticulturist. Processors of fruit, juice manufacturers, bakers, restaurateurs, and others are demanding of the research horticulturist fruits and vegetables that meet their special needs, and no longer does casual observation upon yield and vigor satisfy requirements. At the New York State Station, where variety testing is closely correlated with an extensive breeding program, continued attention was given to the selection of varieties of fruits and vegetables adapted to cultivation in the State.

Fruit breeding and improvement.—Serving the dual purpose of producing genetic facts helpful to future plant breeders and of creating improved varieties to meet the needs of new industries and new uses, fruit breeding continued in 1937 to be an important horticultural activity in several of the stations located in fruit-producing areas. As pointed out by the Minnesota Station as a result of an

analysis of questionnaires distributed in 1935, at least 32 of the State stations were engaged actively in some form of fruit breeding. In the same report the Minnesota Station indicated that from 20 to 25 years are often required to produce and thoroughly test new varieties of tree fruits, such as apple, pear, and plum, and from 8 to 15 years for small fruits, such as raspberries. Correctly it is concluded that the experiment station is particularly adapted to carry on such long-time projects.

In 1937 the New Jersey Station named two of its new seedling peaches, Golden Globe and Goldeneast, and continued also its important work with peach rootstocks. Certain red-leaved seedlings showed considerable promise as stocks and it was pointed out that their general use would prevent the confusion of varieties resulting from the death of the scion and the development of the stock into tree form.

The New York State Station continued its effective breeding program, and among new grapes, the Seneca, an early-maturing, greenish-yellow variety with a high proportion of vinifera ancestry and superb quality, was believed to have a bright future. The Early Seckel pear, similar in color and flavor to the old Seckel, but much larger in size and somewhat earlier in maturity, appeared very promising for the home garden and commercial orchard. Hundreds of seedling filberts, crosses between the American hazel and the European filbert, fruited abundantly for the first time and contained some promising individuals that may well become the foundation of a new industry.

Five promising seedling apples, namely, Franklin, Downing, Kirtland, Warden, and Shaw, were announced by the Ohio Station. Four of these were said to be late-blooming, with the possibility of avoiding late-spring frosts. A promising seedling crabapple developed by the North Dakota Station from a cross of the Delicious apple and the Dolgo crab was named Red River.

In cooperation with the Department of Agriculture, the North Carolina Station originated the Cameron dewberry from a cross between Young and Lucretia. The new variety is said to be more productive than Lucretia, nearly thornless, and disease-resistant. In addition, from a rather wide cross between *Rubus biflorus* of Asia and the Latham red raspberry, the station developed the Dixie raspberry, apparently better adapted to southern environment than are the usual red kinds. Lloyd George, an English red raspberry, used extensively by the Washington and the New York State Stations in their small-fruit breeding, was observed by the former station to be resistant to the insect vector of the mosaic disease, and even more important, to transmit this important characteristic to its progeny.

In the dry summer of 1936 the New York State Station observed that among grapes the Fredonia, Ontario, Agawam, Captivator, Little Wonder, Lutie, and Moyer varieties were resistant to heat and drought.

Improved methods of production.—With consumers more quality-conscious than ever, due to effective and extensive advertising of various food products, there has been a pressing need for improvements in cultural practice that would aid in the production of higher

grade fruits and vegetables. In tree fruits, thinning of the fruit was given careful consideration as a means of improving quality. A type of thinning known as "graduated thinning," in which the distance between apples is based on the diameter of the branch rather than mathematical equality, was found by the Michigan Station to result in an increase in the yield of medium and larger sized fruits. It is recommended by the station that when pruning the apple tree the thinner branches be removed where feasible. Along this same line of thought, the New Hampshire Station urged that vigorous-bearing trees should be pruned lightly by thinning out small branches in the densest portions since heavy pruning was found to reduce the size of the crop to the extent that the increased percentage of fancy grades would not offset financially the loss in total crop. Thinning of the fruit should begin, according to the Michigan Station, as early as the June drop is completed and be finished as soon as possible.

Evidence in favor of early thinning of the apple was also reported by the West Virginia Station, which advised that early thinning not only tends to promote larger size at harvest but in biennial fruiting varieties may decrease the alternate-year tendency. The development of a biennial bearing habit in McIntosh, normally an annual variety, as a result of the almost complete destruction of blooms by a spring frost was overcome by the New Hampshire Station to a considerable degree by heavy fruit thinning in June of the following year. Although rather costly, early thinning is advised for McIntosh trees thrown into a distinct biennial condition by frosts or other factors.

Ringing experiments at the Indiana Station with 8-year-old Grimes Golden apple trees showed that ringing just prior to blooming might increase the percentage of blooming spurs that hold their fruit. At the same time, the heavier set was accompanied by a higher carbohydrate and somewhat lower nitrogen content in the spurs, indicating the importance of adequate nutrition as related to fruit set.

Fruiting in the Black Corinth grape, a variety of which the dried fruits are known commercially as currants, was found by the California Station to be dependent on pollination, as well as girdling of the fruiting canes. Pollination apparently imparted a necessary stimulus to fruit development, despite the fact that no true seeds were formed. The station found also that girdling of the limbs of apricot trees hastened the maturity of the fruit without any harmful aftereffects on the succeeding crop.

Considerable work was done by various stations on strawberry culture. New evidence was reported by the Wisconsin Station on the value of early mulching as a means of preventing winter injury to the roots. At the same time, it was observed that delay in removing mulch in spring may result in loss of vigor in the plants, with the practical suggestion that it is more advisable to risk some injury to the blossoms by early removal of the mulch than to damage the plants by belated uncovering. The value of winter mulches was also pointed out by the Ohio Station with the advice that from 4 to 5 tons of wheat straw are required per acre to provide a 3-inch mulch.

Spacing of strawberries interested several of the stations, and Maryland reported that spacing resulted in large yield increments, particularly when irrigation was provided during the harvest period. Spacing appeared to be effective largely through an increased size of the individual berries.

In studies with wine grapes, the California Station observed that differences in the amount of applied water had no significant influence on taste, acidity, or other demonstrable characteristics of the wine produced.

A rather unique device providing regularly timed explosions of acetylene gas was developed by the Michigan Station for driving robins, starlings, and other fruit-eating birds from the cherry orchards.

Fertilizers for fruit trees.—As indicated in the introductory paragraph, the role of various minor elements created new interest in this and other aspects of fruit-tree nutrition. Many of these studies had a distinctly pathological aspect (p. 89) because of the harmful effects induced by deficiencies. To aid the grower and research worker, the New Jersey Station described the outward manifestations of injury to apples from deficiencies as induced in sand cultures with controlled nutrient supplies. A deficiency of calcium resulted in a very marked stunting, followed by death of stem and root tips. A lack of magnesium caused leaf injury and later abscission. Inadequate nitrogen resulted in yellowish-green leaves with a reddening of the lower leaves, extending progressively to the upper leaves. Root growth was extensive, woody, and abnormally slender. A deficiency of phosphorus resulted in a growth condition comparable to that caused by a lack of nitrogen. The new leaves were small, thin, dark green, and tinged with dark red. Potassium deficiency, manifested more slowly because of free reutilization, curtailed diameter growth in the new wood and the leaves showed marginal injury.

At the California Station citrus trees growing in sand and in solution cultures exhibited symptoms of malnutrition when supplied with adequate nutrients, except boron, and the addition of minute quantities of this element resulted in rapid recovery. Evidence was also obtained by this station, as well as others, that zinc in small quantities is necessary for the proper nutrition of fruit trees. Citrus cuttings growing in sand and in solution cultures showed, in the absence of adequate potassium, leaf scorch, inhibited root development, and numerous rough resinous spots on the leaves similar to low-temperature injury to tipburn caused by excessive chlorine.

Further evidence that nitrogen applied in moderate amounts to apple trees does not decrease the keeping quality of the fruit was secured by the New Hampshire Station. Firmness and color, on the other hand, were influenced by nitrogen, according to the vigor of the tree. For example, on a sandy soil trees low in vigor actually produced better colored and firmer fruits with nitrates, whereas the same treatment to vigorous trees on heavier soils produced lower colored and softer fruits.

An interrelation between nitrogen and phosphorus availability was observed by the Montana Station, where, in the presence of deficient phosphorus, nitrogen reduced the color of apples, while with adequate available phosphorus there was no such response. The value of nitrogen in the restoration of neglected orchards was stressed by the Missouri Station, with the suggestion that such treatment should accompany intelligent pruning, spraying, and other orchard practices.

Of various fertilizers tested for peaches, the Georgia Station reports that 6 pounds of a good-grade mixed fertilizer in spring supplemented with 1 pound of nitrate of soda about June 1 was profitable. Fruit-bud differentiation in the Elberta peach was observed by the Mississippi Station to be delayed from 5 to 10 days by the application of nitrate of soda to the soil, but the delay was not considered sufficient to affect the general condition of the fruit buds.

Pollination studies.—Although many of the problems in fruit pollination are solved, the introduction of new red sports and of many new seedling varieties has resulted in a continuance of observations of considerable interest. Contrary to popular belief, the Washington Station found that honeybees are important in the pollination of the blueberry, doing their part with bumblebees and solitary bees to insure fruit setting. Seasonal effects in the results of the self-pollination of the Bartlett pear were noted by the Vermont Station, where, with the same tree, considerable variation was recorded between different years. Failure in self-pollination in the Bartlett pear was found not to be associated with poor pollen but rather with comparatively slow growth of the tubes down the styles.

Fruit storage and handling.—In storage chambers permitting careful regulation of temperature, the Florida Station observed that 37.5° F. was more favorable for keeping oranges and grapefruit than either higher or lower temperatures. Loss of weight was greater at 37.5° than at 32°, but when various factors, such as keeping after removal from storage, were considered, the higher degree gave the better results. Wrappers such as aluminum foil and moisture-proof cellophane were found superior to paper and ordinary cellophane in reducing losses in weight and in preserving general appearance of both grapefruit and oranges. The simple expedient of covering stacked boxes in storage with canvas tarpaulins was helpful in reducing weight losses.

The important function of ventilation in the keeping of lemons was indicated in investigations carried out by the California Station. Lemons from air-conditioned, refrigerated rooms were superior to those held in naturally ventilated rooms. The favorable results are believed due to the more constant temperature and relative humidity and to the lesser accumulation of harmful substances.

Low-temperature storage, at 35° F., for cranberries was found helpful by the Massachusetts Station in reducing storage losses prior to screening. The keeping quality of apples in storage was improved, according to the observations of the Michigan Station, when the fruit was covered with wax emulsions prior to storage. The same treatment was effective in preventing mold and desiccation in small nursery stock held over winter in storage and also in preventing excessive desiccation in newly planted evergreens. In advice to growers, the Missouri Station pointed out the need of low temperature and adequate ventilation for keeping apples. In autumn it may be better, because of lower average temperature, to hold the fruit in the open air before placing in the storage rooms.

The comparatively new practice of storing fruits in an atmosphere of increased content of carbon dioxide was investigated by the Minnesota Station with the comment that relatively high concentrations of carbon dioxide for short periods will retard the ripening of straw-

berries and raspberries, inhibit the development of molds, and maintain for a longer period the bright appearance of fresh fruits. The most satisfactory results were obtained when the carbon dioxide treatment was combined with a moderate degree of cooling.

Making a careful study of the causes of mechanical injury to apples, the Ohio Station found that the greater part of the bruises originated during grading operations and to a lesser degree during picking. Although washing of tender varieties, such as McIntosh, added to the total bruises, handling prior to and after washing was a more important cause. In case of shipped fruit and vegetables, the Illinois Station found by actual studies during transit that faulty loading and rough handling of the car are important factors in developing injury, and practical suggestions were given for the better handling of shipments.

Spray-residue removal from fruits was studied by several of the stations, not only in the Pacific Northwest, but in the Central and Eastern States. In a comparison of various methods of removing spray residues from apples, the Ohio Station noted that heating the washing solution increased its effectiveness and that washing, if properly carried out, had no injurious effect on keeping quality. Washing did not influence adversely the rates of softening, decay, or of shriveling in storage. The possible injurious effects of accumulated spray residues in the soil were considered by the Oregon Station, with a preliminary conclusion that such deposits do not directly affect the tree because the accumulation is mainly in the surface layers and does not reach the main root systems of the trees. However, it was emphasized that deposition of residues on the soil may interfere with the growth of cover crops and thereby indirectly injure the orchard. Some evidence was secured of increased root absorption of arsenic, lead, and copper and increased assimilation of these elements by the tree and fruit.

Processing studies.—The need of a peach that would hold its attractive yellow flesh color when removed from freezing storage caused the New Jersey Station to study intensively its many varieties and seedlings, with the result that some kinds were found of considerable promise. It was observed that a tannin compound was a primary cause of discoloration and a simple and effective test was developed for determining quickly the content of this chemical and thereby the value, as related to color, of any given peach for quick freezing.

Important contributions were made by the Oregon Station to the art of brining cherries, with the practical result that the tonnage from the Pacific Northwest has increased more than sixfold in a few years. The station's work in improvement of air driers for prunes has had also a wide influence on the processing of this valuable fruit.

Nut culture.—One of the interesting new developments in nut culture is the extensive filbert-breeding project carried on by the New York State Station. With approximately 2,000 seedlings from crosses between the American hazel and the European filbert, and a fine crop in 1937 on many of the trees, there seemed much promise for useful new varieties that would combine the hardiness of the American parent with the quality of the European. The important

relation of the vegetative function of the pecan tree to the proper filling of the nuts was again pointed out by the Arizona Station with the practical recommendation that trees be maintained in a relatively high condition of vegetativeness, but that in summer practices be modified to reduce vegetativeness somewhat to permit the accumulation of starch in the fruiting shoots. The use of ethylene gas was found by the Arizona Station to aid in loosening the husks from the harvested nuts. As a result of extensive studies by the New Mexico Station, the acreage of cultivated varieties of pecans has shown a notable increase.

Miscellaneous crops.—Varietal tests of coffee at the Puerto Rico Station showed the Columnaris variety to be definitely superior to the Santo Domingo, yielding over twice as much poundage. Several of the Southern States, including Florida, Georgia, Alabama, Mississippi, and Louisiana, continued to study the possibilities of tung-oil production. The Florida Station reported that the tung-oil tree does not grow equally well in all locations, but seems to require a rather fertile type of soil. Zinc was found necessary for the tung-oil tree and must be supplied where lacking. One of the outstanding symptoms of zinc deficiency is the bronzing of the leaves, accompanied by poor growth.

VEGETABLE PRODUCTION

Considerable progress was recorded during the year along many lines of vegetable research, notably in the development of improved varieties and the role of so-called lesser nutrients.

Varietal improvement.—Continuing its productive work in cantaloup breeding carried on in cooperation with the Department of Agriculture, the California Station reported that variety No. 45, developed for powdery mildew resistance, now comprises about 90 percent of the cantaloup crop of the Imperial Valley. A resistant variety of Honeydew, No. 60, was also promising, but was still in the process of selection for higher quality. Watermelon breeding at the Virginia Truck Station resulted in the development of promising strains resistant to wilt and anthracnose. An Australian melon similar to the Owens Grey variety gave promise of being valuable and was increased for dissemination to growers. Northern Sweet was the name assigned by the Minnesota Station to a new watermelon variety which matures in from 9 to 10 weeks after planting and which possesses excellent quality. In addition, the station named a new and promising early-maturing pickling cucumber, Mincu.

In search of lima beans resistant to nematodes and wireworms, the California Station imported stocks from Peru and attempted by hybridization with horticultural varieties to combine resistance to the pests with real quality. Among a large number of varieties of peas tested by the New York State Station, Thomas Laxton, Laxton Progress, President Wilson, Morse Market, Gilbo, and Alderman appeared particularly desirable for the market gardener because of their large pods and seed and easy-shelling character, all of which appeal to the housewife.

A new variety of okra, developed by the South Carolina Station and named Clemson Spineless, was disseminated for trial. The new variety appeared to be equal or superior to Perkins Mammoth and

because of an almost complete absence of spines is believed even more desirable. Further observations by the New Mexico Station indicated that the Early Grano onion developed by the station is proving valuable, although it is a little later in maturing than the yellow onion and needs further selection for uniformity in size, shape, and maturity.

Three distinct strains of kale, an important crop in the Norfolk section of Virginia, were isolated by the Virginia Truck Station and stocks of seed increased for dissemination to growers. All three strains showed marked resistance to low temperature, were well-curled and uniform in type. Crosses between heading and nonheading types of collards yielded a nonheading type possessing increased resistance to low temperature. A new variety of spinach selected for resistance to cold and for delayed seed-stock formation yielded more abundantly than the usual commercial varieties.

The Riverside tomato bred by the California Station for its capacity to produce well on soil infested with *Fusarium* and *Verticillium* wilt-producing fungi was described as suitable for canning or shipping. A second variety, Pearson, was recommended as valuable for shipping because of its firmness and tough skin. The fruit had a deep red color, smooth shape, and was of uniform size. The vine is determinate in habit of growth. In the drought period of 1936, the new medium early tomatoes, Early Baltimore and Prairiana, introduced by the Illinois Station, proved superior to late-maturing kinds. The Early Baltimore was the more productive of the two. The Nystate tomato, developed some years ago by the New York State Station from a cross of Ponderosa and King Humbert, continued to show high productivity, even in unfavorable growing years and made a good record also in Ohio, Oregon, Georgia, and Wisconsin. Windsor A, a sweet pepper of high quality developed by the Connecticut (State) Station, appeared highly promising for general culture. A new variety of tomato possessing considerable resistance to a wilt disease was developed by the Missouri Station.

Cultural progress.—Continuing long-time asparagus-cutting trials, the Illinois Station accumulated further evidence showing that cutting too early in the life of the plantation may have an apparently permanent reducing effect on yields. The tremendous vigor of the asparagus plant was noted by the North Dakota Station, where it was found that roots penetrate about twice the depth of the American elm of the same age. In a 35-year plantation, the male plants showed a higher survival than did the females.

Based on a comprehensive statistical study, the Puerto Rico Station found that close planting, 2 square feet per plant, gave the maximum yield of shelled corn per acre, but larger individual ears of marketable quality were produced with 3 square feet per plant. Beyond 3 square feet, production was low in all classes of yield.

That high altitude, even in southern localities, may limit onion culture was indicated by New Mexico trials, in which onions planted at elevations of from 7,000 to 8,000 feet failed to mature either from seedlings or transplanting.

In a study of seasonal factors influencing the quality of tomatoes, the Arkansas Station obtained evidence that precipitation and temperature are the principal limiting influences. Precipitation was followed by an increase in acidity and a slight decrease in invert

sugars, but had no apparent effect on pectin content. Under conditions of high temperature and dryness, the percentage of solids increased. High temperatures caused a decrease in acidity and increased or held invert sugars at a high peak.

Fertilizer requirements.—Refinements in technic for carrying on fertilizer studies have, in recent years, revealed a great number of important facts that were hitherto unknown or barely suspected. For example, the placement studies with commercial fertilizers conducted by several of the stations, often in cooperation with the Department of Agriculture (B. A. Eng.), have shown a considerable wastage of costly materials. However, as observed by the Arkansas Station, in dry seasons there may easily be injury from heavy applications of fertilizers along the plant row, and the station advises that in drought years amounts in excess of 500 pounds per acre may cause trouble.

The differential response to fertilizers of varieties within a species was reported by the New Jersey Station. Large applications of nitrogen that gave good results with large-seeded varieties of lima beans did not increase significantly the yield of small-seeded kinds. A certain variety of tomato responded best to heavy applications of fertilizer in early season, while another variety yielded better when fertilized after the fruit had started to set. Economy and greater effectiveness of fertilization should result from such studies.

The importance of lime for vegetables growing under certain conditions was emphasized by the Louisiana Station, which found that the application of 1,000 pounds per acre of hydrated lime in the drill increased markedly the yields of sweet peppers and of snap beans. A proper balance in fertilizers may, according to the Wisconsin Sation, not only increase the yield of canning peas but also improve the quality of the canned product.

In experiments conducted by the Kentucky Station, marked beneficial effects were obtained, both in respect to yield and quality of tomatoes, by the addition of small quantities of minor elements, such as manganese, copper, zinc, boron, iodine, bromine, and fluorine, to the soil. Which of the elements was the most influential was not established. Manganese was shown by the California Station specialists to be an important nutrient element for the tomato.

In the case of plants growing in water cultures, differing only in the amount of manganese contained, there was noted an association between manganese concentration and total sugars in the plant. That nitrogen may affect the quality of tomato fruits by influencing the degree of fleshiness was indicated in studies at the Rhode Island Station in which it was observed that excessive nitrogen resulted in the development of large cavities and consequent decrease in quality. Experiments conducted on Long Island by the New York (Cornell) Station indicated the need of tomatoes growing on sassafras silt loam for fertilizer containing all of the three principal elements, nitrogen, phosphorus, and potassium.

In studies conducted on the peat soils of the Everglades, evidence was obtained by the Florida Station that several of the lesser elements, such as manganese, copper, and sulphur, are important in plant nutrition. Manganese appeared especially necessary in preventing chlorosis of beans. On another Florida soil a serious defect

in celery, known as cracked stem, was corrected by the application of 10 pounds of commercial borax per acre. Larger applications proved injurious, showing that care must be exercised in the application of borax as a source of boron. The Florida observations were confirmed by investigations by the New Jersey Station, in which it was noted that boron is essential to the normal growth and quality of celery. Boron was observed by the Massachusetts Station to prevent the browning of the heart of rutabagas, and borax was effectively used by growers to correct the condition.

Mushrooms, an important crop in Pennsylvania and other States, received considerable attention during the year. Reduction in the cost of production was made possible by the discovery by the Pennsylvania Station that synthetic composts may be used to replace half the amount of the animal manure commonly employed without reducing the amount of yield. The Iowa Station developed a process for the rapid, high-temperature decomposition of fibrous materials for mushroom beds, in which moisture and air were uniformly distributed through the mixture, and no firefang occurred.

With the revived interest in hop growing following repeal of the Prohibition Act, the New York State Station initiated fertilizer and other studies and secured evidence that hops require a relatively high amount of potash. The station suggested the use of a 4–8–7 NPK formula, varied in quantity per acre according to the fertility of the soil. Supplemental side dressings of nitrogen are suggested where growth is slow, but late-season applications of nitrogen may cause damage by softening the cones. Seedless varieties of hops without leaves in the marketable product were found to bring higher prices than the ordinary material.

Storage of vegetables.—A simple but effective method of storing small quantities of root crops, such as beets and turnips, was reported by the Missouri Station. The roots, after careful cleaning, were placed in earthen or stone jars equipped with loose-fitting board covers.

The waxing of tomato fruits was found by the Montana Station to greatly lengthen their potential storage life.

Thorough ripening in the field is, according to the New York State Station, an important consideration in the keeping of winter squash. In advance of severe frosts, the squash should be gathered carefully and covered with cornstalks to permit curing prior to actual storage. Among varieties found to be well adapted to long storage were Warted Hubbard, Blue Hubbard, Improved Green Hubbard, Warren Turban, Bay State, Marblehead, and Banana.

Fruit-setting studies.—The honeybee, long recognized as an important factor in pollination of fruits, was observed by the Massachusetts Station to be the most important insect pollinator of onions, and recommendations were made to onion-seed producers that they place bees near their fields.

Working on causes of poor setting in the pepper plant, the New York (Cornell) Station reached the conclusion that unfavorable temperature and unfavorable water supply are important factors involved in the dropping of buds, blossoms, and immature fruits. Adequate nitrogen was also concerned in the setting of fruits.

Partial defloration of the tomato plant by the removal of the later-formed flower clusters was observed by the Arkansas Station to result in larger size of the remaining fruits, but not to cause any advance in the date of the first harvest. Stating that during the hottest part of the summer the usual tomato varieties will grow in the Winter Garden section of Texas with irrigation but fail to set fruit, the Texas Station reported some progress in the development of new tomatoes which will set fruit in midsummer although so far the fruits are seedless in that season.

ORNAMENTAL HORTICULTURE

The improvement of flowering plants by scientific breeding is generally acknowledged as a largely unexplored field and one in which great progress may be expected in the near future. Some valuable progress has been made in the past by the stations in the development of disease-resistant flowering plants, notably the work done some years ago by the Wisconsin Station in the selection of *Fusarium*-wilt-resistant China-asters and by the Indiana, Massachusetts, and California Stations on the development of rust-resistant snapdragons. In rose culture, the South Dakota Station reported some progress in the development of thornless varieties adapted to the severe conditions prevailing in the Northwest. In the South, where high temperature becomes an obstacle to successful rose culture, the Arkansas Station found considerable difference in the behavior of varieties, with Black Knight, Betty Uprichard, Nellie E. Hillock, and Edith Nellie Perkins listed among the more heat- and drought-resistant kinds.

Propagation studies.—Growth-promoting substances, such as indoleacetic acid, gave promising results at the Rhode Island Station in the propagation of *Daphne cneorum* cuttings, both by increasing the percentage of successful rootings and by hastening rooting.

Observations on the seeds of aquatic plants led the New York (Cornell) Station to the conclusion that the seeds of most aquatics should never be allowed to dry but should be stored in water just above the freezing point until time to plant in spring.

Culture.—Light influences on growth and blooming interested several of the stations. A considerable number of species were tested by the New York (Cornell) Station as to their photoperiodic response, and the following were found to bloom earlier than usual when submitted to short days: *Chrysanthemum morifolium* (var.), *Callistephus chinensis*, *Piqueria trinervia*, *Euphorbia fulgens*, *E. pulcherrima*, *Eupatorium coelestinum*, *Bougainvillea spectabilis*, *Begonia socotrana*, and *Kalanchoe blosfeldiana*. The station suggests that the normal date when day-length abbreviations would start bud formation is the date to start lengthening the photoperiod to delay flowering. Attempts by the Ohio Station to follow chemically the changes in chrysanthemum plants subjected to short days showed no great differences in chemical composition as compared with normal-day plants. Starch was absent or present only in very small quantities in the tips and stems at the time of flower-bud initiation in both groups of plants, and nitrates were absent at the time of flower-bud initiation in both groups. Supplemental light was used successfully by the Ohio State University to retard the blooming period of late varieties of chrys-

anthemums, in some instances as much as from 28 to 35 days. At the Alabama Station, manipulation of the photoperiod was employed successfully in lengthening the blooming period of asters, and blooms produced under shade were of better quality and less subject to disease.

Minute quantities of gas escaping into the atmosphere of the greenhouse may cause serious injury to the plants, according to investigations by the Michigan Station. Some of the manifestations were drooping of leaves, leaf yellowing, and, in extreme cases, defloration. The placing of a highly sensitive plant, such as the tomato, in a suspected environment was recommended as a ready index of possible injury.

J. W. Wellington.

FORESTRY

Thousands of acres of Southern cut-over pine lands have been replaced by inferior species of hardwood, according to the Alabama Station, which reported the possibility of renewing the pines by planting on areas not too completely taken over by hardwoods. According to the Pennsylvania Station, in the second-growth oak forests, over 25 percent of the total number of stems, and their basal area, was found to have developed from sprouts. In the less fertile soils the percentage of sprouts was even greater.

Records taken by the Vermont Station showed that pasturing of maple groves is an almost universal practice and that continued heavy pasturing is destroying a large portion of the natural reproduction of the maple. From a study of soil factors affecting tree growth, the Arkansas Station concluded that soil features influencing available water are apparently more influential than any others in determining the rate of growth of pine trees. The important function of forest litter in the welfare of the forest and in preventing erosion was pointed out by the Connecticut (State) Station with the statement that where there is a favorable relationship existing between the forest floor and the mineral soil, the removal of litter is quickly detrimental to the whole soil structure.

J. W. Wellington.

PLANT PESTS AND DISEASES

All types of plants are attacked by a great variety of insect pests and diseases. Some of these are ever present and cause a steady drain on agriculture while others are spasmodic, being little in evidence in the average year, then suddenly flaring up into such intense and widespread destruction as to create a major national calamity. Early agriculture was almost helpless in the face of such losses. In fact, comparatively little progress in the practical control of crop pests and diseases had been made prior to the time of establishment of the State experiment stations. These institutions, together with the Department of Agriculture, accepted as an important part of their responsibilities the investigation of such troubles and the development of the scientific means for lessening the tremendous losses due to them. During the past 50 years these agencies have succeeded in working out measures for suppressing many important plant parasites and noxious insects and introducing them into effective general use throughout the country with a resulting reduction in losses that

has frequently brought rescue to some branch of agricultural production and in the aggregate has made enormous returns on the public funds invested in this field of research.

The State agricultural experiment stations have made excellent progress in their work on plant diseases and pests during the past fiscal year, starting out with more than 600 separate investigational projects dealing with plant diseases alone and nearly as many with plant-destroying insects.

Current research in this field has so increased in amount and diversity that only a comparatively few examples can here be given to show the wide range of these efforts and to point out something of their significance and value. The illustrations used in the following paragraphs give little indication of the extent to which scientists in different institutions are working on a particular problem or of the large extent to which the research referred to may be included in cooperative regional or national group programs.

PLANT SELECTION AND BREEDING FOR DISEASE AND PEST RESISTANCE

A large number of important plant diseases and insect pests cannot be dealt with effectively or economically by direct control measures. Therefore, an extensive program for the development of crop varieties possessing inherent resistance or tolerance to attack has grown up in the experiment stations, often aided by the Federal Government. Plant selection and breeding for resistance are included in more than 200 individual projects in 50 State and Territorial stations. They cover every major type of crop and an increasing number of minor crops. They aim to discover resistance to such troubles as rusts, smuts, mildews, blights, scabs, wilts, root rots, nematodes, viruses, chinch bug, hession fly, corn borer, plant lice, leafhoppers, and the like, and to combine such resistance with high yield, high quality, and adaptability to particular soil and climatic conditions. Specific reference to typical results of such plant-breeding work will be found in the sections of this report dealing with research in field crops and horticulture.

To give a basis for more effective disease-resistance breeding methods, many stations are carrying on fundamental studies on the nature and inheritance of resistance. To cite a few examples, the Maine, Maryland, Kansas, and Wisconsin Stations, working with Federal cooperation, have recently developed valuable information on the way disease-resistance factors are transmitted to the offspring in potatoes with respect to late blight and virus diseases, in sorghums with respect to the "milo" disease, and in beans with respect to the common mosaic. The Minnesota Station has also reported important findings on the complex inheritance of virulence in the fungi causing the smut diseases of barley and oats.

NATURAL AND BIOLOGICAL CONTROL OF PLANT DISEASES AND PESTS

By natural and biological control of pests or disease-producing organisms is meant their suppression by other living organisms or biological agents which are capable of destroying or inhibiting them. A few examples of current station work along this line follow.

Natural and biological control for plant diseases.—The pioneer studies in this comparatively new field as related to plant disease are still in the exploratory stages, but substantial progress is being made, and although practical applications are still for the most part in the future, it appears probable that in this direction lie improved chances of control for some of our most baffling crop maladies. There is even promise that facts developed through such research may some day be used in devising soil-management systems that will enable antibiotic organisms to work effectively on a large scale in the control of such destructive and refractory diseases as root rots of cereals, potato scab and *Rhizoctonia*, flax wilt, cotton root rot, etc.

A common soil fungus (*Trichoderma*) has recently been found by the New Jersey Station to produce a diffusible principle toxic to the scab and *Rhizoctonia* organisms, two of the most widespread and difficult-to-handle diseases of the potato crop. A soil bacterium was also found that produces a substance toxic to the scab parasite. The New York (Cornell) Station has isolated bacteria antagonistic to the destructive fire blight organism (*Bacillus amylovorus*) of apple and pear trees which experimentally, to some extent, could prevent blossom infection on the trees and even inhibit infection already started.

The viruses responsible for the yellow and green mosaic diseases of sugarcane are, according to the Louisiana Station, distinct, but both do not occur on the same plant since a plant infected with one virus is in some way rendered immune to the other. A sort of acquired immunity to a virus disease has been demonstrated by the Wisconsin Station, in cooperation with the Department of Agriculture (B. P. I.), in experiments where tobacco plants, after recovering from initial effects of "streak," showed an apparent immunity to further infection although still carriers of the disease. It is suggested by such results that protective inoculation with mild strains of certain diseases may eventually prove useful, especially with plants ordinarily propagated not by seed but by vegetative means as in the case of potatoes, sweetpotatoes, sugarcane, fruits, many trees, shrubs, bulbs, ornamentals, etc.

An important example of indirect natural control is disclosed by the Western Washington Station, which found that the Lloyd George variety of red raspberry, though susceptible, completely escapes natural infection by the destructive red raspberry mosaic through its resistance to the aphid (*Amphorophora rubi*) that carries the virus. Several other varieties were also found to show marked resistance to this insect.

Biological control of insect pests.—On the entomological side, biological control methods have attained not only a broad and solid scientific foundation, but they have also long since reached the stage of wide practical application. Typical of the more recent findings along this line, the following cases may be cited.

A reduction of oriental fruit moth infestation has been traced by the New York State Station to certain parasites, and particularly to one known technically as *Macrocentrus ancylivorus*, which was introduced from New Jersey in cooperation with the Department of Agriculture (B. E. & P. Q.) and liberated in western New York where its effectiveness in controlling this orchard pest appears to be steadily increasing.

In a study of cherry casebearer parasites, the Wisconsin Station reared some 32 species from this one insect alone.

The ladybird beetles constitute a group of well-known predators which are among the most beneficial of insects and are particularly useful on the Pacific coast in the control of scale insects. A Chinese species introduced by the California Station into the citrus groves of that State has survived two winters and is spreading satisfactorily from the original center where it was set free and around which it now occurs over an area of 15 miles radius. A number of attempts to introduce and establish in the United States certain species of small parasitic insects (Aphelinidae) for the control of citrus scale have in the past repeatedly failed. Recently the reason has been ascertained through work by the California Station. Unmated females of these species produce only male offspring, while mated females produce only females. The latter are primary internal parasites, developing only in the scale insects which they kill. The males, on the other hand, are secondary parasites, developing only by feeding on their sisters as well as on other parasitic insects which they kill and naturally prevent from reproducing. Through the use of this new knowledge of their habits, these parasites may be so manipulated as to obtain both sexes in proper proportion at the proper time and thus to employ them successfully for scale control without jeopardizing their perpetuation.

Among the forms of foreign scale-inhabiting parasites recently described by the California Station is one from South Africa which proves to be a true internal parasite of the California red scale. Its successful introduction is of special interest since previous world-wide search had disclosed no internal parasite of this most serious citrus pest, and it was thought perhaps to be immune.

Insects which might aid in the control of Puerto Rican pests have been sought by the Puerto Rico Station cooperating with the Department of Agriculture (B. E. & P. Q.), with the result that at least 12 species of great promise have recently been introduced into that Territory. Among them are parasites of various thrips, of the sugarcane borer, and of scale insects of coconut and other plants.

CHEMICALS AND SPECIAL METHODS USED FOR PLANT DISEASES AND INSECT CONTROL

In no direction has the United States advanced more rapidly in recent years than in the field of chemistry. Agriculture has benefited from this in many ways and nowhere more strikingly than in the development of new and more effective chemicals for combating plant diseases and insect pests. A very large amount of work is now going forward in the State experiment stations, not only in inventing and testing out new materials and combinations of materials, but in studying their modes of action and their effects on plants. Study is also being continued on the older materials as a guide to increased effectiveness and greater safety in their use. The examples presented below give but a small indication of the extent of activities along these lines.

Fungicides.—Much work has been done in the past and is still going on to perfect the use of sprays for the protection of plants during the growing season against countless infectious diseases at-

tacking leaves, stems, or fruit, but far too little has been done to develop means for eradicating the sources from which such infections come. The Wisconsin Station, however, has recently presented the encouraging results of more than 10 years of pioneer effort to find out how to accomplish this very thing. It has been shown to be possible with certain new combinations of copper, lime, and arsenic, properly applied, to prevent almost all winter survival of apple scab in the orchard by a single spraying. Similar action was demonstrated in small-scale tests in which other stations cooperated in the case of pear scab, brown rot of stone fruits, apple blotch, peach scab, raspberry spur blight, cherry leaf spot, and thread blight of fig. This list includes some of the most widespread and destructive of orchard diseases. Preliminary work at the same institution indicates that a solution of ammonium sulphate, well known fertilizer, applied on fallen apple leaves may also be able to prevent the discharge of the microscopic spores that start apple scab going in the spring.

Bordeaux mixture, one of the earliest and most successful of fungicides used for protecting various crops against diseases, has been studied intensively by the New Hampshire and West Virginia Stations, particularly as to the effects of using different combinations in its preparation. So-called insoluble copper fungicides have been tested out as substitutes for bordeaux on crops frequently injured by the latter. The Ohio Station reports promising results with basic copper chloride for disease control on tomatoes and cucumbers. Tests are being conducted in various places with the copper zeolite spray material recently developed at the Delaware Station as a bordeaux substitute, to determine its range of usefulness. Red copper oxide is another relatively new fungicide, advanced by the New York State Station, which is being widely tested for the control of various diseases. The Louisiana Station reports this material effective in trials against damping-off of various truck crops in the seedbed.

A combination of rosin and lime-sulphur was found by the California Station to be very effective from the standpoints of covering power on the foliage, resistance to weathering, and protection from infection by the hop and onion downy mildews, which are often highly destructive and very difficult to control.

Working with the common types of damping-off caused by *Pythium* and *Rhizoctonia*, the Massachusetts Station has developed a promising new method of killing these fungi in the soil, which was both effective and at the same time as safe as formaldehyde in tests with seedlings of beets and 13 kinds of ornamental plants. Acetic acid, the acid of vinegar, was mixed with powdered charcoal and the powder mixed with the soil just before the seeds were planted and the soil was watered. Ordinary cider vinegar itself mixed with the soil was found reasonably effective and relatively safe in tests with 10 kinds of flowering plants, beets, cabbage, lettuce, and tomato when used at the rate of about a cup per square foot.

In trying to prevent damping-off by using formaldehyde-impregnated dust, many stations have had variable results difficult to explain. The Ohio Station showed the reason for this to be that the strength deteriorates rapidly with marl, muck, gypsum, or charcoal while other absorbent materials like kaolin, infusorial earth, sawdust, and grain hulls hold the strength well for as long as 13 months.

One of the problems of spray-residue removal is the danger of sound apples and pears coming in contact with the spores of decay accumulated in the wash water. In a study of the effect of the different types of washing solutions on the life of the most important rot-producing spores, the Washington Station found that the spores of gray mold (*Botrytis cinerea*), a troublesome soft rot producer, were unable to survive contact with these solutions. Sodium silicate proved most toxic to the spores, hydrochloric acid next, and sodium carbonate least. All were more effective with increasing temperatures.

Insecticides.—Increasing activity was manifest throughout the country in the search for and testing of new or little-known insect poisons with special emphasis on materials that will have no harmful effect on plants, on man and animals, or on the soil. The insecticidal properties of 41 derivatives of cyclohexylamine were tested by the Illinois Station, using an aphid and the red spider mite in this work. Applied as contact poisons, two of these were found to be exceptionally potent.

Of 121 water-soluble organic compounds tested as stomach poisons by the New Jersey Station, 7 gave promise of usefulness.

Approximately 1,000 different compounds were tested over a period of 3½ years by the Delaware Station in the search for materials nonpoisonous to man and higher animals. The thiuram sulphides gave excellent control without severe plant injury, proved more effective as repellents than the commonly used lead arsenate, and promised to be of commercial value against adult Japanese beetles.

A new form of cryolite, tested further by the Tennessee Station, is shown to have superior properties for spraying or dusting with no evidence of foliage injury on apple, peach, potato, bean, cucumber, and tobacco and to give better control of sweetpotato flea beetle and Mexican bean beetle than certain arsenicals while offering, in the opinion of this station, no public health hazard. A soapstone-fluorine compound was also announced as a promising insecticide.

One percent of free nicotine dissolved in a completely volatile, highly refined, colorless, odorless, and tasteless petroleum distillate has been found by the Kentucky Station to be a promising horticultural spray for field or greenhouse use. The toxicity was found equal to that of 0.1 percent of pyrethrum in oil.

Much work is going forward to determine the way insecticides act in an effort to secure guiding facts for the development of greater effectiveness. The New Hampshire Station used the cockroach to test the penetration of arsenic in contact with the body. One form of arsenical was shown to pass into the body much more slowly than another, in fact so slowly that the insect may eliminate it, largely through the digestive tract, as rapidly as it enters the body.

The effects on the cockroach of the fumes of three contact insecticides have been tested by the Iowa Station. It took much longer to kill with nicotine than with pyridine or piperidine, but less of the material was required. This station has also contributed to our knowledge of the difference in sensitiveness of closely related insects to certain insecticides. For example, it took much stronger solutions of nicotine and sodium oleate soap to kill gladiolus thrips than onion thrips. The same station found great differences in the sensitiveness of caterpillars such as the corn earworm, armyworm, silkworm,

and *Datana* species to such insecticides as rotenone and its derivatives, lead arsenate, certain coal-tar dyes, etc. The connection between the chemical structure and effectiveness of nicotine and related compounds has been studied extensively by the Iowa Station.

The more finely pyrethrum powder is ground, according to work by the New Jersey Station, the more quickly it paralyzes or kills the insect but the more quickly exposure to light reduces its toxicity. This deterioration was found temporarily checked by tannic acid or titanium dioxide. Potato plants were found by the New York State Station to be attractive to the green peach aphid if covered with a light colored coating like bordeaux, and the same proved true for the cabbage plant louse in which case the use of dyed dusts, best of all black-dyed dusts, on cabbage reduced the numbers of aphids present as compared with those on the plants dusted with undyed lead arsenate and lime.

The methods and apparatus for applying insecticides have been investigated by many stations. Working on airplane and autogiro dusting problems, the New Jersey Station found that with lead arsenate the speed with which the dust settled on the foliage was increased by adding oil to the dust while better distribution of the dust particles could be obtained by adding celite, the finer the better.

In working on insect fumigation, the California Citrus Experiment Station found that when penetration of the fumigant into soil, burlap sacking, etc., is required, sustained vacuum fumigation is much more effective than either atmospheric or dissipated vacuum fumigation, although under other conditions the difference is not great.

Much work has been done by the stations on adjuvants. Karaya gum has been shown by the Illinois Station to be an effective agent in increasing the toxicity of red spider sprays in greenhouses while the Kentucky and Louisiana Stations have found it effective in nicotine-soap sprays for aphids or thrips. Studies on the range in quality and performance of different commercial blood-albumin spreaders and the effect thereon of different types of earths have been reported on recently by the California Citrus Experiment Station. That the chemical relationship between a spray and the waxy skin of the leaf may affect the manner in which a spray wets and spreads on the leaf is indicated by work at the New Jersey Station. Tests with three neutral wetting agents (sodium salts of sulphonated diphenyl compounds) gave evidence that certain of them may be effective and harmless to plants when used in making wettable sulphur sprays, or as emulsifying agents with many oils, or as a spreader in bentonite nicotine spray for codling moth control, or as a wetting agent with derris for European red mite or apple aphids, proving compatible with hard water. Of several materials used as spreaders and stickers with insoluble copper sprays, the Delaware Station found that colloidal clays like bentonite and kaolin do not reduce their effectiveness, and a specially prepared bentonite appeared to surpass these in promoting adherence or persistence of the spray. Similar results were obtained by the Ohio Station, which also found Wyoming bentonite suitable as a carrier for soluble or gaseous fungicides and insecticides.

Spray injury.—The stations in the Cumberland-Shenandoah fruit section are working together on the spray-injury problem. The Pennsylvania Station finds evidence that each of the principal in-

gredients of the common copper- and sulphur-containing sprays is capable of producing serious injury that cannot be entirely avoided, but it has developed programs of sprays for apples which promise to minimize this as much as possible. High pressure was found by the West Virginia Station to be a predisposing factor with weather conditions constituting the most important influence, so that all copper fungicides cause fruit russet at times, particularly with high temperatures. That leaf growth in apple trees was not affected by sulphur-containing sprays unless leaf scorching occurred was demonstrated by the New York (Cornell) Station.

Soil sterility from arsenic accumulation as a result of continued spraying or dusting for insect control is of concern to many States. A number of stations are focusing attention on this problem. A valuable discovery by the New Jersey Station in cooperation with the Department of Agriculture (B. E. & P. Q.) is that in certain soils the injurious effects of arsenic accumulation following Japanese beetle control may be eliminated by the application of certain iron compounds.

Poisoning of honeybees by arsenicals used in insect control has created a serious problem. Now the New Jersey Station reports on tests indicating that rotenone dusts are as toxic to bees as the arsenical dusts.

DISEASES AND PESTS OF GRAIN CROPS

A large amount of research has been devoted to the pests and diseases of the highly important grain crops, and in this work the State experiment stations have been extensively assisted through the cooperation of the Department of Agriculture. This research has resulted in remarkable improvements in the varieties grown and in the success with which many major insects and infectious maladies are being combated.

Diseases of grain crops.—With regard to the widespread, destructive, and refractory smut disease of corn, the Iowa Station has recently brought to light important facts regarding the infectivity and virulence of the causal fungus. Of the total visible infections found, a large percentage was at the joints and favored by increased bud growth and by lateness in planting. Crown infection by the fungus *Diplodia zeae* that destroyed nearly 27,000,000 bushels of the 1936 Iowa corn crop has been studied by the same station. This type of attack was found to occur in 14 to 52 percent of the field corn during a recent season, resulting in discoloration and disintegration at the base of the stalk and serious loss in yield. Infection from the soil occurred through wounds made by emerging roots and was most severe with high soil moisture. Mercury dust treatments of the seed appeared to inhibit the fungus without killing it, but the delayed invasion from the soil thus brought about lessened the crown infection. Selfed lines of corn have furnished some remarkably resistant strains now being used in breeding work.

Progress is being made in the control of wheat smut even though it still causes large losses. A drop from 40.5 in 1931 to 7.9 in 1937 was reported in the percentage of cars of wheat grading smutty in the month of August at the Oregon and Washington terminals. This drop is attributed largely to the work done by State agricultural

agencies with Government cooperation in encouraging better seed treatment and the use of more resistant or smut-escaping varieties. In recent tests of seed disinfectants for wheat bunt (stinking smut), the Washington Station has found basic copper sulphate to be as effective as copper arsenite or carbonate, often giving complete protection against seed contamination. Not only was there no injury to treated seed held for nearly a year, but germinability was improved and the fungicidal action of the dust was not lessened. Copper arsenite dust proved as effective as copper carbonate in reducing soil infection. Trench seeding as compared with normal drilling gave less bunt. Two additional physiological races which must be considered in wheat breeding have also recently been reported, and four wild grasses were found to be susceptible to one or the other of them.

The often serious reductions in viability of wheat ("sick wheat") have been shown by the Ohio Station to be due to the toxic byproducts of certain nonparasitic fungi, including molds, which are associated with the grains both in the field and in storage, but which become sources of danger only when the moisture content of the grain is high and the temperature favorable for mold growth.

In the *Gibberella* scab disease, growers of wheat and barley, in the upper Mississippi Valley especially, have a plague affecting yields in a disconcerting and erratic manner. The same fungus also causes an enormous amount of seedling blight. The chief hope for its control has been placed on resistance. In field and greenhouse tests with seed of selected wheat and barley varieties produced in several localities of the United States and Canada the Wisconsin Station, in cooperation with the Department of Agriculture (B. P. I.), found the environal conditions under which the seed had been grown to affect its susceptibility to both seedling blight and bunt. The results as a whole suggested that differences of a nutritional or biochemical character were more important in resistance than structural or size differences in the seed.

A bad disease of winter barley is the *Rhynchosporium* scald studied from many angles by the Indiana and Wisconsin Stations cooperatively with the Department of Agriculture (B. P. I.). Orchard grass scald was found to be due to a new species of this fungus, differing from the one on barley, rye, and other grasses, and six highly specialized races of the latter, an important matter in breeding for resistance, were discovered.

A serious rice trouble involves a deficiency in green color that lowers the yield. Sulphur and sulphuric acid are reported by the Arkansas Station to have corrected the alkaline soil condition held responsible for this trouble, increased the effectiveness of fertilizers and the availability of iron, and to have given higher yields. Sulphur at 1,200 pounds per acre also proved effective in reducing the severity of stem rot of rice.

The problem of diverse physiological races among the organisms causing plant diseases has claimed the attention of investigators ever since the method of using resistant varieties has been applied to their control. The Minnesota Station, which has worked long in this field, has recently summarized for the benefit of others the methods it has developed for determining the physiological races of some of our

most destructive plant parasites and particularly of the smuts, rusts, and other fungus diseases of cereals.

Insect pests of grain crops.—The European corn borer, a destructive introduced insect which is spreading in the United States, commands continued attention by station workers. Burning, though in general not a good farm practice, was found by the New Jersey Station to be one of the effective methods for disposing of infested materials that cannot be fed or entirely plowed under. Disking prior to seeding the land is considered objectionable under borer conditions, and the general use of insecticides is believed too expensive.

Some strains of corn appear to possess inherent resistance or tolerance to borers, and breeding along such lines is in progress at various stations. Work with hybrids, inbreds, open-pollinated varieties, and top crosses is reported by the Indiana Station. From them selections are being made to provide a wide variety of plant characters which might have a bearing on resistance. A spray procedure has been developed by the Massachusetts Station through the use of which 90 to 95 percent of an early sweet corn crop was rendered borer-free, and the few infested ears were 60 percent marketable. A significant feature was that a large proportion of the increased yield occurred in the first two pickings when the market price was at the highest point. In spray tests by the Connecticut (State) Station, cooperating with the Department of Agriculture (B. E. & P. Q.), phenothiazine compared favorably with nicotine tannate standard in reducing the numbers of borers, and of several dusts employed a newly developed preparation, dual-fixed nicotine consisting of nicotine tannate and nicotine bentonite, gave a degree of control consistent with commercial requirements.

With regard to the corn earworm, the New Jersey Station found that removal of the silk before the eggs have hatched reduces the number of infested ears as much as 55 percent and the insects 7 to about 80 percent. In general, the early plantings of corn receive the lowest number of eggs during the silking stage, midseason plantings a larger number, and late plantings the highest number of eggs, according to reports by the Maryland and Virginia Stations. Cryolite, applied by the Idaho Station to the silks twice at an 11-day interval, proved effective in preventing injury from this pest, and the Maryland Station reports a 60- to 80-percent reduction of injury when barium fluosilicate or lead arsenate was applied at intervals to keep the silks covered. Good results were also obtained from fall plowing and use of resistant varieties.

Certain varieties of sorghum and corn were found by the Oklahoma Station to be more or less resistant to chinch bug attack, and it was concluded that the most promising method for reducing damage is to use locally adapted resistant varieties. Of the corn varieties tested Hays Golden proved most dependable in this respect. Sorghum varieties differed greatly in ability to withstand drought and chinch bug attack, but Atlas sorghum proved highly resistant to both under local conditions. Varieties of feterita, milo, and milo derivatives tended to be susceptible. Where chinch bugs were abundant, early planting proved advantageous since the earlier plantings, being further advanced at the time of chinch bug migration to the field, showed less injury and produced the highest yields, while late plant-

ings were frequently destroyed. Detailed studies on the longevity, development, and egg laying of this widespread and destructive insect in relation to its host plants have been conducted by the Oklahoma Station in cooperation with the Department of Agriculture (B. E. & P. Q.).

Important information on the relation of humidity and temperature to chinch bug survival in different stages and seasons and the results of extensive laboratory and field tests on the effectiveness of a large number of contact insecticides have been reported by the Iowa Station. In the field, laundry soap was as effective as commercial potassium oleate and potassium fish-oil soap and less injurious to the plant. Nicotine was more toxic to adults than to the younger stages of the insect, and pyrethrum extract in dilute acetone solution proved highly toxic. Rotenone and the derris extracts were less effective in the field than in the laboratory. Dipyridyl oil was noninjurious to the plant at effective concentrations. All the dusts tested proved valueless or impractical.

The hessian fly is charged with annual wheat losses averaging $13,000,000. Valuable facts about its life history and progress in the breeding of resistant wheats from crosses between desirable winter wheats and Marquilo (a spring wheat carrying resistance both to this pest and to stem rust) have been reported by the Kansas Station. A large number of hybrids have been tested at several stations in cooperation with the Department of Agriculture (B. E. &. P. Q.), and promising types of both hard and soft winter wheats have proved highly resistant.

Black grain-stem sawfly, first discovered in the State in 1934, is reported by the Ohio Station to have survived the extreme cold of the winter 1935–36. It appears able to withstand any type of climatic conditions likely to occur there. Previous observations were confirmed as to the advisability of harvesting infested wheat as early as possible.

Against both the granary and the rice weevils responsible for large annual losses in stored cereals, 12 fumigants were tested by the Minnesota Station and in 11 cases the latter species proved definitely more susceptible. It may thus become possible to correlate a single physiological difference in these two insects with the differences in reaction to a group of fumigants. In the twelfth instance the rice weevil was three times as resistant to sulphur dioxide as was the granary weevil.

COTTON DISEASES AND PESTS

The ravages of cotton-destroying insects and diseases are well known. Never has the effort by experiment stations in the Cotton Belt to meet the problems created by them been more intensive, and never have the combined efforts of the Federal Department of Agriculture and these stations been more effectually coordinated. An important influence in bringing this about was the formation of all State and Federal cotton-disease investigators into the Cotton Disease Council, organized at Jackson, Miss., in 1936 to facilitate group planning and conduct of research and exchange of information and materials. Seedling disease and cotton wilt studies are being conducted cooperatively on a large scale under this council.

Diseases of cotton.—Damping-off or sore shin of cotton, the cause of which had been a question, was shown by cooperative studies of the South Carolina Station with the Department of Agriculture (B. P. I.) to be due to the cotton anthracnose fungus (*Glomerella gossypii*) rather than to the nematodes previously suspected. The latter, however, proved able to increase the stunting of the seedlings in combination with certain other injurious fungi (Fusaria). Progress toward more effective control of these serious seedling troubles is now made possible.

The original incidence of cotton root rot (*Phymatotrichum omnivorum*), the most destructive American disease of cotton, its rate of spread, and the overwintering of the disease were found by the Texas Station to be greater in alkaline than in acid soils. Additions of manure, fertilizers, or trace elements failed to reduce the overwintering, but relatively small amounts of sulphur mixed into the soil reduced the percentage of root rot, though not eradicating it. Sulphur applied to the surface finally made the soil acid to depths of more than 2 feet. The practical applications of the method are promising, though still in the exploratory stages. In an investigation of possible wild hosts in an undisturbed Texas native hay meadow, this station found some 37 out of a total of 47 plant species to be more or less susceptible to the root rot fungus, the grasses, however, not being attacked. Additional susceptible plants were found in various other meadows of the Blackland Prairie belt. The station therefore recommends that meadows and pastures be kept free of weeds, not only to starve out the fungus but also to produce a hay of better quality and to secure a thorough grass covering for combating soil erosion. In a long-time rotation study at the Temple, Tex., Substation, 4-year rotations of cotton with the nonsusceptible corn, oats, wheat, or sorghum showed a consistent root rot reduction while 3-year rotations did not.

The bacteria causing angular leaf spot, another locally and seasonally damaging malady of cotton, were demonstrated by the Oklahoma Station to enter the seed through the porous spongy tissues at the base, and bacterium-laden raindrops and run-off water were shown to be the principal sources of infection. Treatment of cottonseed (fuzzy or delinted) by the Texas Station with various fungicidal dusts for planting purposes resulted in an increased stand and in many cases in higher yields. Such treatment of delinted seed also reduced the number of plants infected with angular leaf spot in the early seedling stages.

A fairly high potash content in the general-purpose fertilizers used on cotton was found by the Mississippi Station to be definitely beneficial in the control of *Fusarium* wilt and rust (potash-deficiency effect) in numerous fields and soil types of the Delta region where these diseases are of major importance. On severely infested soils the use of a cotton variety at least relatively resistant to wilt in combination with a high potash fertilizer has greatly reduced the injury from both these causes. Potash deficiency has been shown by the Arkansas Station to increase definitely the susceptibility of cotton to wilt, and early applications of potash proved more effective than later applications.

With reference to rust, an increase in the potash application by 25 pounds of K_2O above that usually applied was found by the North Carolina Station to increase the yield and improve the quality of the cotton. In a survey of the occurrence and extent of cotton wilt infection, the stations in the cotton States, cooperating with the Department of Agriculture (B. P. I.), found but little evidence to support the belief that either soil and other environal factors or different strains of wilt vary so greatly that cotton resistant in one region may be highly susceptible in another. Extensive cooperative studies are now in progress to obtain more light on the true situation. Eleven species of insects were found by the Texas Station in cooperation with the Department of Agriculture (B. E. & P. Q.) to act as natural carriers of this wilt. In one test the causal fungus remained alive for 15 months in dried fecal pellets from grasshoppers fed on wilt-infected cotton stems.

Insect pests of cotton.—The distribution of cotton root aphids, which constitute a problem in the South Atlantic States, has been mapped by the South Carolina Station in cooperation with the Department of Agriculture (B. E. & P. Q.). Detailed observations are also presented on the relation of temperature to their life histories and on the relation of these subterranean insects to their host plants, which may aid in developing means of control.

The flower thrips causing serious damage to cotton in certain areas and also attacking many other plants, but with a preference for certain groups, has been studied by the South Carolina Station. Thrips injury was shown to be negligible after cotton had reached the age of about 6 weeks. Heavy, dashing rains were apparently the most important natural means of control. Insecticidal methods have not proved satisfactory, but certain cultural procedures were found to be of value, including early planting, clean culture, growing cotton as far as possible from forage and cover crops, and promoting rapid growth from the start.

TOBACCO DISEASES AND INSECT PESTS

Tobacco growing has an unusual north and south geographic range extending from Connecticut and Wisconsin to Florida. This makes it subject to a considerable variety of diseases and insect pests, many of the most important of which are particularly difficult or impossible to control by the ordinary older methods. The State and Federal plant pathologists associated with the organization of tobacco specialists in the Southeastern States known as the Tobacco Research Committee established the Tobacco Disease Council (1935) at Greensboro, N. C., to make possible the joint consideration of disease problems and more effective mutual assistance and pooling of resources in working them out. The value of this undertaking became so apparent that in 1937 at Tifton, Ga., the Federal and State entomologists working on tobacco insects organized a Tobacco Insect Council with similar objectives. The Tobacco Disease Council, the Tobacco Insect Council, and the Cotton Disease Council represent probably the first attempts on the part of groups of investigators working in a single scientific field to organize voluntarily for more effective Nation-wide attack on the problems of a single major crop.

The advantages of such a scheme to the branches of agriculture concerned are already making themselves apparent.

Diseases of tobacco.—Tobacco mosaic constantly lowers the value of the crop in all tobacco-growing regions. Studies by the Wisconsin Station cooperating with the Department of Agriculture (B. P. I.) indicate that the virus survives in sufficient quantity in harvested tobacco and in field refuse to account for infections from such sources. Furthermore, cigars and cigarettes sometimes carried fairly high virus concentrations, but other forms of commercial tobacco carried little or none. In field refuse the virus was largely inactivated when fully exposed to weathering and decay for 5 to 6 months, but high concentrations survived in infected roots until the succeeding crop was set out. In the absence of freezing and drying, some virus may also survive as long as 2 years in close association with the soil. Although direct infections from the soil may not be abundant, subsequent dissemination from plant to plant accounts for still higher percentages of mosaic.

A species of groundcherry (*Physalis subglabrata*) collected from pastures and fence rows 2 months after tobacco had been harvested on the Kentucky Station farm was found to be infected with the bacterial angular leaf spot or blackfire disease. In the face of these results, this and perhaps other related weeds must now be considered in dealing with the introduction and spread of this serious disease of tobacco.

A handbook on tobacco diseases, dealing with the causes, soil relationships, and recommendations for control, has recently been published by the Kentucky Station.

The blue mold or downy mildew of tobacco swept through the major tobacco-growing areas in 1937, causing the most widespread and destructive seedbed epidemic since it invaded the United States in 1921. The disease can be effectively and profitably controlled by a spray consisting of one-half pound of cuprous oxide, 1 quart of Lethane spreader, and one-half gallon of cottonseed oil to 50 gallons of water, as demonstrated by the Georgia Coastal Plain Station, cooperating with the Department of Agriculture (B. P. I.). Additional tests indicated that it can be perfectly prevented and controlled by evaporating either dimethyl benzene (xylene) or benzol in pans set inside the seedbeds at night underneath tightly constructed covers. Hotbeds with air temperatures maintained at or above 70° F. most of the time also proved effective in preventing severe damage. However, the spray treatment was by far the cheapest and involved no radical change in accepted practices.

Tobacco resistant to black root rot and of a satisfactory commercial quality has been the aim of the Massachusetts Station, and most promising results in its efforts to produce such a strain are reported. There also is evidence that some of the older nonresistant varieties are being gradually displaced.

Insect pests of tobacco.—The potato flea beetle has been found by the Connecticut (State) Station, cooperating with the Department of Agriculture (B. E. & P. Q.), to be the most injurious of all insects infesting tobacco in the Connecticut Valley. In experimental control work under shade tents with cube root powder (4 percent of rotenone), barium fluosilicate, and sodium aluminum fluoride diluted with

sterile tobacco dust gave the highest number of dead beetles and next to the least leaf injury. In comparative tests on Havana seed tobacco of dust mixtures consisting, respectively, of 1 percent of rotenone, barium fluosilicate with tobacco dust 1 to 3 by volume, a proprietary rotenone mixture, and equal parts of cube root powder (1 percent of rotenone) and barium fluosilicate, there was very little difference in effectiveness, all treated plants showing a distinct improvement and the dust residue on the leaves not being objectionable except with the last-mentioned mixture. Sunflowers planted as shade with Havana seed tobacco proved effective in luring the flea beetles away from the tobacco. The use of power machinery for summer applications of poison dusts resulted in very even distribution, and the efficiency of power spraying was proved by the great reduction in flea beetle injury and the coverage of a large acreage in a short time.

SUGAR PLANT DISEASES AND PESTS

Certain virus diseases constitute major problems in both sugar beet and sugarcane production. Relative to the destructive curly top of sugar beets, the California Station in cooperation with the Department of Agriculture (B. P. I.) obtained strong evidence that the virus is most closely associated with the food-conducting system of affected plants. The virus content of infected immature beet seeds was very low, but increased to a very high concentration in the mature seeds. No virus could be recovered from the pollen or from the embryo plants within the seeds even though the seeds were heavily charged with virus. In fact, such seeds germinated readily and the developing embryos utilized the stored food in other parts of the seeds without themselves becoming infected. In dry seeds the virus became inactivated within 3 months. It thus appears that the disease cannot be spread by pollen or by seed. The list of host plants has been extended by this station through experimental transmission of curly top to 92 species of ornamental flowering plants in 73 genera belonging to 33 families, thus proving that these plants may under certain circumstances become hosts of the virus and potential agents in the spread of this extremely serious handicap to the sugar beet industry. As new contributions to practical control, the Idaho Station cooperating with the Department of Agriculture (B. E. & P. Q.) has developed two strains of sugar beet (26A and 25D) which appear to be unusually high in yield as well as resistant to the curly top disease.

Atomized petroleum oil, kerosene, and pryethrum were found by the Idaho Station to be effective in killing the beet leafhopper, the sole insect responsible for spreading the curly top disease of beets and other crops. Kerosene proved nearly as effective as the more expensive petroleum oil for use with pyrethrum.

Southern root rot (*Sclerotium rolfsii*) of sugar beets has been investigated by the California Station, with the result that control measures have been developed and put into practice and that the disease is no longer considered a serious threat to the sugar beet industry in central California where over 14,000 acres are known to be infested. Proper sanitary procedures, including the disposal of dump dirt, are most important. In addition, it has been shown that cattle fed on infested fields may spread infection, but the most im-

portant problem of management is a proper rotation, since the fungus kernels (sclerotia) largely responsible for actual infection diminish rapidly when beets and certain other suspectible crops are kept off the land. Crop systems involving wheat, barley, peas, or winter fallow, without summer irrigation, reduced the sclerotial population to the point where beets could be safely grown after some 3 to 5 years. Methods have also been developed for a biological assay of the soil to determine the sclerotial populations as a guide to planting practice.

An organic mercurial seed treatment proved effective in controlling damping-off, the principal cause of poor stands of sugar beets in Minnesota, according to cooperative work by the Minnesota Station with the Department of Agriculture (B. P. I.).

As a result of field tests of various commercial sugarcanes and new seedling selections with respect to losses from mosaic and red rot (*Colletotrichum falcatum*), the Louisiana Station has found that several of the newer varieties meet the disease-resistance standards satisfactorily and ensure high production. Rapid spread of red rot may be explained in part by the discovery that it is possible for the fungus spores to travel through the water-conducting tubes of the cane, strongly suggesting that this is what occurs when cut stalks become infected at planting time.

In a general study of the fungus causing dry top rot of sugarcane, the Puerto Rico Station has recently pointed the way to reducing sugarcane losses through differences in varietal susceptibility. The disease is said to become most severe on poorly drained soils, and the most important method of distribution from place to place is by seed cuttings.

FORAGE, RANGE, AND COVER CROP DISEASES

With the growing attention given to erosion control, soil building, and restoration of submarginal land once in cultivation to permanent vegetational cover, the importance of range and pasture grasses and of leguminous forage and cover crops in the national economy has come into general recognition. Observations indicate that failures in establishing ground cover of this sort and the running out of stands which have been attributed to lack of satisfactory adaptation are in fact often due to the attacks of various parasitic organisms about which our knowledge is at present limited. Considerable study has already been given to some of the more conspicuous diseases of major forage crops, and much selection and breeding work has been instituted in the effort to develop productive strains of these plants resistant to certain of the generally important maladies. The following are examples of the progress that is being made.

Diseases of forage legumes and grasses.—An abnormal yellowing and stunting of alfalfa, apparently a common difficulty in North Carolina, is reported by that station to have been corrected within the season by applications of ordinary borax (5 to 10 pounds per acre) in March, while similar treatment late in May produced no visible effects until the following year.

In studying the effects of the troublesome dwarf disease on alfalfa plants, the California Station, cooperating with the Department of Agriculture (B. P. I.), has found one of the most characteristic

symptoms to be the development of a yellow discoloration in the wood, owing largely to the formation of gum, which finally involves the entire root system, while the starch gradually diminishes and almost disappears just prior to the death of the plants.

Black stem disease of alfalfa, common in Idaho, has been shown by the Idaho Station to be identical with one reported earlier from Kentucky. The life history cycle of the causal fungus (*Pleospora*) was worked out, and it was found that the spores from the overwintering stage start the disease going on alfalfa in the spring.

Alfalfa losses reported by the Wyoming Station in that State were found to be due mostly to a gradual thinning out of the stands by the widespread bacterial wilt disease. There was no evident relationship with either available soil phosphorus or soluble soil salts, but increases in its incidence were always associated with increased numbers of plants showing winter injury. This points to the necessity of looking to wilt- and cold-resistant types to prevent future wilt losses.

The susceptibilities of some 20 different species of clovers (*Trifolium*) to the red clover powdery mildew have been determined through field, greenhouse, and laboratory tests by the Indiana Station, cooperating with the Department of Agriculture (B. P. I.). Of the 14 proving susceptible in varying degree, 10 are believed to be new host records for this fungus parasite. From collections secured in various parts of the United States and Canada, three physiologic forms were distinguished. An effective method for determining physiologic forms and host susceptibility was developed which should aid in selection and breeding for resistance.

Snow mold (*Fusarium nivale*) causes widespread injury to grasses, particularly the bentgrasses. The Michigan Station has shown them to vary greatly in resistance, and has classified them according to their reactions to this disease. Continuous use of organic nitrogenous fertilizers such as cottonseed meal, dried blood, etc., appeared to increase the injury from snow mold, while mercuric fungicides proved effective in controlling it.

The susceptibility of a large number of grasses to root rot (*Cercosporella*) has been indicated through a cooperative study in the field and greenhouse by the Department of Agriculture (B. P. I.) and the Oregon, Idaho, and Washington Stations. However, most native range grasses proved sufficiently resistant to avoid serious injury under semiarid conditions and thick stands.

Insect pests of forage legumes and grasses.—The practical use of the sun in controlling cowpea weevils was demonstrated by the Kansas Station. Exposure of the seed to open sunlight on a clear day with no wind between the hours of 10 a. m. and 4 p. m. and with shade temperatures of 98° F. or over for a period of 75 minutes resulted in the complete destruction of all stages of weevils that infested them. Similar exposure for as long as 5 hours did not seriously injure germination provided the shade temperature did not exceed 100°.

The establishment of dry-weather legumes (alfalfa, sweetclover, and red clover) in permanent bluegrass pastures without plowing was found by the Wisconsin Station to be an effective means of controlling white grubs and of renovating pastures.

Satisfactory control of heavy hairy chinch bug infestation of turf on Long Island by insecticidal applications for the two broods in June and August, respectively, has been reported by the New York (Cornell) Station. Better results were obtained with two treatments for each brood using tobacco dust (1 percent nicotine) or cube dust (1 percent rotenone) at the rate of 25 pounds per 1,000 square feet each time than with a nicotine-soap spray.

The velvetbean caterpillar is reported by the Louisiana Station to have been a serious pest of alfalfa in the southern part of the State during the late summer and fall of 1936. An insect parasite of the eggs and a parasitic fungus were found reducing the infestation in some areas, but at present its practical control is limited to the use of poisons on fall seedlings or postponement of fall planting to prevent defoliation by the caterpillars.

The mysterious yield-depressing malady of peanuts known as pouts was shown by the North Carolina Station to be due to the feeding of the same poisonous leafhopper that damages alfalfa, clover, garden beans, soybeans, potatoes, and cotton, thus now opening the way for its effective control through the use of spray treatments.

POTATO DISEASES AND PESTS

Potato culture has been attended by a constant fight against numerous perplexing and destructive diseases and insect pests. The damage thus caused often fluctuates violently, causing exceptional instability in the commercial production of the crop and in the prices received. Many State experiment stations have long conducted investigations looking to the better understanding and control of this difficulty. The results are being utilized by growers everywhere and have brought about systems of potato-seed certification and disease control that have greatly improved conditions in recent years. What is in effect a national program for scientific potato improvement has been under way in which the Department of Agriculture is cooperating with many States in working out old and new problems, including those created by diseases and pests. Some of these activities are reflected in the following paragraphs.

Diseases of the potato.—A disease of as yet unknown origin and cause, which in some areas has become a limiting factor in potato production, was reported by the West Virginia Station. Among the prominent symptoms are dwarfing and other abnormalities of the leaflets, browning of the sap-conducting strands and pith, and death of the stem and of the tubers.

An apparently new and dangerous form of bacterial wilt and soft rot which is not yet generally distributed and the organism of which had not yet been fully identified was also reported and described by the Maine Station. It occurred most commonly on Green Mountain, but also on Irish Cobbler and Katahdin potatoes.

Potato-seed treatment with formaldehyde dust followed by immediate planting was found by the New York (Cornell) Station to reduce attack by the "Z" disease, resembling a form of *Fusarium* wilt, which has spread alarmingly of late in western New York, but it was noted that serious yield decreases may result if extreme precautions are not observed in its application.

One of the fungi (*Fusarium oxysporum*) responsible for the potato wilt of Nebraska, Colorado, and adjoining States, has been shown by the Nebraska Station to be essentially a stem rot organism, differing from typical wilt-producing Fusaria of other crops in its wide distribution, occurrence on virgin soils, and in its weak parasitism. A second species (*F. solani eumartii*) is primarily a root rot organism which sometimes also causes a stem rot. Such precise determination of causes is essential to working out a program of defense.

A serious disorder of Brown Beauty potatoes resembling the curly dwarf disease and suspected to be of virus origin, was reported by the Colorado Station. First observed in 1933, it has now become increasingly prevalent and is being further studied by this station.

A method of inoculating (plug grafting) potato tubers with the virus of yellow dwarf disease used by the Michigan Station in testing potato seedlings for resistance brought to light several promising seedlings that apparently fail to take the disease even under heavy field infection.

The vein-banding virus, a constituent of the potato disease known as rugose mosaic, was found by the New York (Cornell) Station to be transmitted in the true seed in a small percentage of cases with some evidence that entry of the virus may take place through infected pollen. These findings are of extreme significance in potato-breeding programs.

With respect to potato scab, the Indiana Station showed that high soil temperatures greatly increase and intensify the disease. Under Long Island acid-soil conditions, addition of yellow oxide of mercury or calomel to the fertilizer mixture reduced the scab infestation, in tests by the New York State Station. In a region with relatively alkaline soils, formalin seed treatments by the New York (Cornell) Station consistently gave small reductions in scab, but both soil and seed treatments with mercurials resulted in increases. In western New York tuber defects were markedly decreased by ammonium sulphate in the fertilizer mixtures. The Netted Gem variety proved rather highly resistant to serious scab injury, slight differences in resistance apparently existed in Smooth Rural, and Blossom Cobbler was considerably more resistant than Irish Cobbler. An exhaustive study of the scab and related micro-organisms in the soil and on the factors which influence their persistence and pathogenicity was reported by the Vermont Station. Counts of the scab bacteria proved to be highest in winter when the soil moisture was highest and lowest from May to October when the soil moisture was at a comparatively low ebb. Disinfected Green Mountain potatoes planted on sandy loam soil after an absence of potatoes for 19 years produced about 70 percent of clean tubers, 26 slightly scabby, and 3 percent badly scabby, whereas the previous potato crop had been approximately 99 percent badly scabby. The disease thus had reappeared in milder form producing a superficial russet, but the probability that virulence might be regained if potatoes were continued was suggested.

Late blight (*Phytophthora*) of potatoes was reported by the South Carolina Station to have developed in the coastal section of the State only five times in 20 years. By means of rainfall records taken during the earlier part of any season it is now possible to determine

the time and frequency of spray applications advisable in that area. This has already saved the growers needless expense in seasons when spraying was unnecessary.

In a report on the bacterial brown rot of potatoes troublesome in parts of the South, the Florida Station gave the distribution and economic importance of the disease and the known host plants. Crop rotations and weed eradication were ruled out as ineffective combative measures, but in experimental field plats the malady was controlled by soil treatment with single applications in May or June of sulphur at 400 to 1,200 pounds per acre. Yield reductions due to this treatment were found preventable by subsequent use in November or December of 2,000 to 3,000 pounds of limestone per acre. Green Mountain and Katahdin proved most resistant and Chippewa and Spaulding Rose most susceptible to the brown rot.

Potato-seed treatment is almost universal, but to know which treatments are best is important. In 5-year seed-treatment tests by seven different methods in three localities by the Wyoming Station using various fungicides on *Rhizoctonia*- and scab-infected Bliss Triumph and Irish Cobbler potatoes, mercuric chloride gave the best average of disease-free tubers and the best average yields. Ammonium sulphate used as a fertilizer gave some reduction in scab in unirrigated plats.

Both cut potato seed and desprouted whole tubers were found by the Vermont Station to be susceptible to injury by certain disinfectants, particularly formaldehyde and corrosive sublimate. Though normal cork offered protection, that regenerated on cut surfaces proved much less effective. It is concluded that cut tubers to be disinfected should first be allowed to regenerate a new skin by storage for at least 5 days in a damp, cool place, and that calomel, yellow oxide of mercury, or one of the organic mercurial dips should be employed with prompt and thorough drying.

Potato-seed treatment with yellow oxide of mercury definitely delayed emergence in tests by the New York State Station on Long Island. This did not affect the ultimate growth of Irish Cobbler but did reduce that of Green Mountain plants. Stem infection by *Rhizoctonia*, even when soil-borne, was reduced. Treatment of seed pieces at time of cutting or planting sometimes resulted in decreased yields, but when applied at least 4 weeks before planting, no injurious effects were noted.

Bordeaux spray tended to increase the total foliage in tests on Long Island by the New York (Cornell) Station, but at the same time it retarded early tuber growth, although final yields were not always affected.

Though the root knot nematode (*Heterodera marioni*) was reported by the New York State Station to be a serious pest of Long Island potatoes, it is believed unlikely to spread much beyond its present distribution. Winter conditions proved too mild to eradicate or materially reduce infestations, and the more common weed species on potato soils were found to be hosts of this parasite. Control by chemical means is deemed too costly or otherwise impracticable, but clean cultivation for two seasons as a summer fallow is recommended for suppression of this nematode.

59024—38——6

Insect pests of the potato.—Heavy infestations of European corn borer larvae on potato plants were found by the Virginia Truck Station in cooperation with the Department of Agriculture (B. E. & P. Q.) to reduce the yields markedly. Infestation by this insect was observed to increase very rapidly with favorable weather conditions, making it a potential menace in bad years on the Eastern Shore of Virginia.

Blister beetles, serious on potatoes, were found by the North Dakota Station to be effectively controlled by barium fluosilicate. The potato leafhopper on dahlia, potato, and alfalfa was effectively repelled in experiments reported by the Michigan Station through white coatings of the foliage with such substances as flour, lime, and talc. Kerosene steepate of pyrethrum was found by the Wisconsin Station to be quite specific in its toxicity to potato leafhoppers, while a similar steepate of derris proved to be specific to potato flea beetles.

TRUCK-CROP DISEASES AND PESTS

The production of truck crops has risen to the position of a major industry in American agriculture. In the large-scale production of garden crops for the market or cannery the problems created by plant diseases and insects have been among the most difficult to cope with, and to stabilize commercial production, effective and economical means of holding them in check must be adopted.

Attention has been directed to the failure of many standard vegetable varieties to succeed in the South. This is probably due in no small measure to the susceptibility of these varieties to diseases and pests common and destructive in southern latitudes. An important step forward was taken when the southeastern experiment stations undertook a definite program of vegetable breeding for southern conditions centered around the Department's Bankhead-Jones Regional Laboratory for Vegetable Breeding at Charleston, S. C.

The results of recent experiment station investigations are exemplified below.

Truck-crop diseases.—The *Phoma* rot of tomatoes has become since 1915 one of the most important causes of spoilage in winter shipments from a number of the southern States. Observations by the Florida Station indicate that it occurs more extensively when the weather is mild and humid than during warm, dry seasons. In spray tests bordeaux mixture (4–4–50) gave increased yields of marketable fruits and largely prevented rot in storage, but during warm, dry seasons this spray reduced the yields of salable fruits. The rot was further diminished by washing with various chemicals immediately after picking, borax proving slightly the best of the materials used. Among the varieties tested, Livingston Globe, Marglobe, and Pritchard showed most resistance to infection.

Leaf mold in greenhouse tomatoes is dreaded because it defies control by sprays. The Ohio Station has contributed to the solution of this problem by crossing the resistant Red Currant tomato (*Lycopersicum pimpinellifolium*) with the susceptible but otherwise desirable Globe variety. Three or four resulting strains were found to be completely resistant, equal to Globe in yield, and of slightly higher quality.

Tomato collar rot, stem canker, and early blight, all due to the fungus *Alternaria solani*, have been reported as causing severe losses in southern Georgia. Cooperating with the Department of Agriculture (B. P. I.) in an intensive study, the Georgia Coastal Plain Station has found severity of attack to be in proportion to the amount of rainfall and relative humidity. In cooperation with northern States, work was begun to find effective preventive measures since Georgia tomato plants are shipped north to be set for the main summer crop in the most important tomato-producing areas.

In a cooperative study of pathogenic organisms on tomato seed, the New York State Station and the University of Georgia have accumulated evidence that commercial seeds are a large source of primary seedling infections and have developed a method to determine the presence of important pathogens on seed and thereby to test the effectiveness of measures designed to insure disease-free seed. The New Jersey Station found that soaking tomato seeds in solutions of corrosive sublimate (1:2,000 or 1:3,000) for 10 minutes satisfactorily disinfected them, and the Indiana Station learned that seeds internally infected could be avoided by proper selection of seed fields along with effective roguing and sorting, while scalding the fruit and thorough washing of the seeds greatly reduced the surface contamination. For subsequent surface sterilization and protection, certain organic mercurials showed considerable promise.

Different virus diseases are serious problems with tomatoes and other truck crops. The California Station has developed a method of employing 600-mesh carborundum powder for the successful artificial inoculation of plant viruses that have been difficult to transmit by other methods, such as the spotted wilt virus affecting many plants and certain mosaics of celery, cauliflower, and sugar beet. This technic, now widely used, has done much to speed up plant-virus research.

A new type of *Fusarium* wilt of tomato has been reported by the New York State Station as occurring in an important truck area. The future possibilities of its spread and damage are as yet unknown.

In a study of tomato spraying, the Ohio Station found that oil emulsion added to bordeaux mixture would counteract the depressing action of the latter on yield. Of certain copper sprays which depressed yields less than bordeaux, copper oxychloride appeared most promising. Tomato plants survived setting out best if not sprayed for several days before and after transplanting with any material which, like bordeaux mixture, makes the leaves lose water faster. The value of this finding may well extend to other crops.

Peas, beans, and related plants suffer from many virus diseases. The Idaho Station showed that most plants of this family are subject to more than one virus disease, with one usually predominating. Furthermore, the important fact was demonstrated that sweetclover and red clover serve as overwintering hosts of certain viruses of peas and beans. In order to determine the host range of the most important pea virus, the common mosaic, which was given special study, nearly 2,500 plants representing 94 species were inoculated, but infection was noted only in the legume family. The 62 garden and field pea varieties tested varied in resistance to the disease. No evidence of seed transmission was found.

Two different pea virus diseases, "enation" and "severe" mosaic, destructive to pea plantings, especially in western Washington, were studied by the Washington Station and found rarely transmitted in the seed. Therefore, control practices must be directed to the suppression of insect transmission. Severe mosaic was found to have a wide host range among legumes, while enation mosaic proved more limited in the species affected.

A garden pea disease of the streak type was found by the Wisconsin Station to be due to the thrips-carried spotted wilt virus. The known facts indicate that this disease may be widespread in the United States as well as abroad.

Careful examination of 6,500 samples of pea seed by the New York State Station showed certain disease-producing micro-organisms commonly present and capable of suppressing emergence, growth, and stand. Seed treatment with copper or zinc preparations was recommended by the Illinois Station for the elimination of seed-borne diseases of peas and soil sterilization for the control of damping-off. Graphite dust (1½ to 2 ounces per bushel) added in treating pea seed with red copper oxide was found by the New York State Station to be an effective means of reducing seed friction and drill breakage.

Differences in susceptibility of snap bean varieties to the widely distributed powdery mildew, which is of economic importance especially in the fall crop throughout the southeast, have been observed by the South Carolina Truck Station. Sulphur dusts or sprays gave good control.

The common yellowing and death of beans and other crops on reclaimed Everglade peat soils was shown by the Florida Station to be due to manganese deficiency, which could be corrected by acidifying the soil with sulphur, treating it with manganese sulphate, or spraying the crop with manganese sulphate solution.

Club root, an almost universal, soil-borne disease of crops of the cabbage family, was found by the New Jersey Station to be materially reduced by mixing metallic mercury with the fertilizer.

A new virus mosaic disease of cauliflower described by the California Station frequently causes considerable loss in the cool coastal valleys of the State. Three species of plant louse were found able to transmit this disease to which no less than 51 vegetable varieties, 3 ornametals, and 5 weeds, all belonging to the cabbage family, were found susceptible.

A fungus root rot (*Phytophthora*) of cauliflower was shown by the California and Missouri Stations to be responsible for losses in the winter crop of the coastal districts of California where the soil had become waterlogged, occurring also on cabbage, brussels sprouts, cineraria, and stock.

Boron deficiency was demonstrated by the Maine and Massachusetts Stations to be the cause of water heart or dark center of rutabagas, which the latter station found could be corrected by 10 to 20 pounds of borax per acre. These results confirm the findings of the New York (Cornell) Station for cauliflower and other plants, and it thus becomes apparent that many soil areas are probably deficient in available boron.

The *Fusarium* wilt of cantaloup was reported by the New York State Station as spreading and becoming increasingly destructive

in the State, with total losses on thoroughly infested soils. The fungus parasite was shown to be present throughout the entire infected plant, to be seed-borne, and to remain infective in the soil for at least 2 years. Tests indicated that it should be possible eventually to develop satisfactory resistant cantaloup strains.

A rot of Honeydew melons in California developing in soil that had become waterlogged from poor drainage was shown by the California Station, with the aid of the Missouri Station, to be due to a fungus, *Phytophthora capsici*, which proved pathogenic to 14 plant species. The California Station also reported a soft rot of pumpkin due to a typical soft rot type of bacterium.

Onion mildew has proved periodically destructive and hitherto largely uncontrollable in many parts of the country. The Oregon Station found bordeaux-type sprays apparently not suffciently effective for satisfactory control, while lime-sulphur burned the foliage and fungicidal dusts proved impractical. However, remarkably specific fungicidal action was shown by an aniline dye, malachite-green, used with a spreader or in combinations with red copper oxide.

The destructive onion smut fungus was found by the Wisconsin Station to parasitize Welsh onion seedlings, but later they developed resistance and threw off the disease. Welsh onions also proved to have more resistance to damping-off than common onion seedlings.

The troublesome onion pink root and bulb rot disease complex in its relationships to two fungi (*Phoma* and *Fusarium*) was worked out by the Iowa Station. Both seed and soil treatments proved ineffective, but selection and breeding of Red Globe and Yellow Globe onions resulted in five strains in which losses from bulb rot in both field and storage were less than 5 percent.

Cracked stem of celery, a noninfectious trouble causing large losses to growers, was described by the Florida Station and reported to be a symptom of boron deficiency. It proved to be preventable by soil applications of borax, while spraying the material not only prevented cracked stem but actually increased the yield.

In control tests for celery leaf blights by the Michigan Station, no superiority of the newer fungicides was found over the old copper sulphate-lime combinations. Therefore, spraying with bordeaux mixture (8–12–100) and dusting with copper sulphate-lime (20–80) are recommended.

The *Fusarium* yellows disease of celery, since first observed in 1913, has been destructive in Michigan districts of intensive production and has been reported from most celery-producing States, where in some sections it has caused serious losses. Two distinct forms of the parasite were found generally in Michigan. Eradication tests proved the ineffectiveness of chemical treatments but demonstrated the effectiveness of steaming the soil. Certain cultural practices were recommended as palliatives and above all exclusion of the parasites from uninfested soil. Desirable resistant strains of celery developed by the Michigan Station continued to show their superiority.

An important disease of head lettuce called drop (*Sclerotinia sclerotiorum*) was described by the Arizona Station as it occurs in that State. The probable value of acidulated mercuric chloride or of sulphuric acid for localized soil disinfection was indicated by laboratory

tests. Careful handling and precooling were advised for reduction of decay during shipment.

For a serious and apparently new disease of cultivated mushrooms appearing in that State, the Missouri Station has developed a novel method of control consisting of trenches 6 inches wide dug around the infected area and 6 inches in advance of the diseased mushrooms. The serious bubble disease of mushrooms has been found by the Pennsylvania Station to be controllable by steam sterilization of the beds. The New Jersey Station found that while production was at first somewhat retarded by steaming the mushroom beds, the third and fourth pickings yielded considerably more than those obtained from untreated beds.

Insect pests of truck crops.—Several stations have reported work on combative measures for pea aphids which have at times seriously threatened the pea industry. Soap and nicotine sprays were found by the Maryland Station to give large decreases in infestation and increased yields, while derris dust with spreader gave even larger yields. The Wisconsin Station, cooperating with the Department of Agriculture (B. E. & P. Q.), also obtained effective results with derris sprays and dusts. The Florida Station brought nature into the picture in devising a control method in the Everglades areas through building up the early-season ladybird beetle population so that there were enough of them to hold the aphids in check during the commercial pea season.

In view of the fact that the Mexican bean beetle is now firmly established in New York, especially in the Hudson Valley and on Long Island, the New York State Station has issued recommendations for the use, wherever practicable, of bean varieties that make a rapid, vigorous growth and the selection of planting dates which will dodge the periods of greatest injury from this pest. For types requiring a long period to develop, both spray and dust treatments were recommended.

Poisonous leafhopper control on beans has been effected by the Texas Station through an efficient and relatively inexpensive treatment consisting of a mixture of finely ground sulphur dust and ground pyrethrum flowers.

The corn earworm is one of the most widespread and destructive of insect pests and feeds on several important crops, including the tomato. In tests of various sprays and dusts, the Ohio Station obtained the best control (over 96 percent of sound tomatoes) through spraying by the use of lead arsenate with a sulphonated alcohol spreader. Of the dust treatments, paris green-lime-sulphur gave about the same results.

A mite was reported by the Ohio Station as first appearing in greenhouses of the Cleveland area in 1933 and causing a white, moldlike appearance on tomato plants. This condition was shown to be due to an abnormally heavy growth of hairs. Although reported on field tomatoes in Florida as early as 1892, this is said to be the first record of injury by this mite to a greenhouse crop in the United States. Sulphur fumigation between crops was said to be the most hopeful control measure.

Control of the pavement ant, which during the last few years has seriously injured many fields of eggplants in the Norfolk area,

has been studied by the Virginia Truck Station. Many materials tested proved unsatisfactory, but several gave promising results. Of these, naphthalene flakes gave the most lasting protection but apparently had a retarding effect on growth when in contact with the roots.

Fall dusting tests on kale infested with young caterpillars of the diamondback moth, conducted by the Virginia Truck Station, indicated that if applied when the larvae are young either a derris talc or a cube talc dust of proper strength will give satisfactory control.

Tests of pyrethrum dust mixtures for control of young larvae of the zebra caterpillar and of the cabbage looper under field conditions were continued by the New York State Station. The most notable features of the results were the greater effectiveness of dusts having a stock pyrethrum powder of lower pyrethrin analysis and the lower effectiveness of dusts diluted with clay than those diluted with talc, gypsum, or infusorial earth. Cabbage worm control studies continued by the Ohio Station led to the recommendation that paris green-lime dust or a spray of paris green with spreader applied at high pressure be used at about 10-day intervals, except for 2 weeks before harvest. For later applications on cabbage and for all applications on cauliflower, broccoli, brussels sprouts, kale, or rape properly diluted derris was recommended to avoid arsenical residue.

Wireworms are among the most important pests of cabbage, cauliflower, horseradish, beets, and other vegetables in the market-garden area of northern New Jersey. Emulsions containing one-eighth ounce of carbon bisulphide and 1 gram of either paradichlorobenzene or naphthalene per plant were found by the New Jersey Station to give an average of better than 80-percent kill of this pest. Carbon bisulphide with crude chipped naphthalene was the cheapest combination used, and it also proved more effective than nicotine sulphate soap against onion thrips.

ORCHARD DISEASES AND PESTS

Wherever fruit and nut trees are grown diseases and insect pests have constantly threatened to eliminate orcharding as a profitable phase of permanent agriculture. That station plant pathologists and entomologists are actively assisting the growers in meeting such problems is shown in the following pages.

Orchard diseases.—No single fruit disease is probably of wider importance outside of irrigated regions than apple scab. Many stations continually study to improve local spraying and dusting practices and to learn the value of newly introduced materials. Under Hudson Valley conditions, the New York State Station found that lime-sulphur after the first cover spray may be dangerous and advised less caustic substitutes, ending with the last cover spray to protect against fall scab infections. The Ohio Station worked out recommendations involving the use of different materials for scab sprays, depending on the susceptibility of the particular variety both to scab and to spray russeting. Some of the more important Ohio varieties were rated on these points. Comparatively mild strengths of lime-sulphur gave satisfactory control with better foliage and fruit conditions if applied thoroughly and at the right time. Apple varieties were also rated as to scabbiness by the New York State Station.

Summer drought and high temperature, according to the Illinois Station, do not eradicate scab once it has started.

The fact that fire blight has completely wiped out commercial pear production in many sections and that it is a constantly recurring problem difficult to deal with in many apple varieties is sufficient reason for continued research on this, the first plant disease proved to be caused by bacteria through the pioneer work of Burrill in Illinois. Fire blight bacteria were proved by the Arkansas Station to be capable of multiplying in the nectar of pear flowers and of penetrating through the nectary into the undeveloped fruit, and the effectiveness of bordeaux sprays applied twice to the open blossoms for reducing blossom blight was confirmed. The discovery of hair-like strands of fire blight bacteria exuding from infected pear fruits and shoots and permitting wind dissemination of the disease, a possibility never before suspected, was reported by the Wisconsin Station. That increases in fire blight injury generally follow nitrogen fertilization was noted by the New York (Cornell) Station. This station, as well as the Ohio Station, found cultivation to favor blight while sod in the orchard repressed it but reduced the crop. Alfalfa in the apple orchard was found by the New York (Cornell) Station to be productive of better growth than sod while permitting less blight than clean cultivation, and the Ohio Station found the use of straw mulch with pears a better practice for reducing fire blight damage than growing alfalfa, which tended to reduce soil moisture too much in dry seasons.

The bacterial canker and blast of pear and that of stone-fruit trees, both common and often destructive on the Pacific coast, were shown by the California Station to be due to a single bacterium (*Phytomonas syringae*). Evidence was also presented that certain widespread diseases of other plants are caused by this organism. Important information acquired on varietal resistance to this germ and on its mode of action has given a foundation for future control work.

Cedar rusts are periodically and locally important throughout the eastern apple regions. Recent spray tests by the New York State Station using various copper and sulphur fungicides indicated effective control to be possible with lime-sulphur, wettable sulphurs that leave a heavy coating, and with bordeaux mixture if applied thoroughly and at the right times.

Rotting of apples in storage causes enormous losses everywhere, in the Pacific Northwest blue mold rot being the worst offender. The Washington Station has given much attention to means of preventing it and finds nothing superior to treatment with the relatively inexpensive sodium hypochlorite.

That the troublesome drought spot, cork, rosette, and die-back of apples in the Champlain Valley, apparently related in origin, may be prevented by the use of boron is indicated by encouraging evidence from the New York (Cornell) Station.

Zinc deficiency has been shown by the research work of various stations to be the cause of many widely distributed, baffling, and crippling diseases of orchard crops. Particularly important has been the mottle-leaf of oranges and grapefruit studied by the California, Florida, and Puerto Rico Stations, which have also been working

on the best means of supplying the needed zinc to correct the difficulty without injury. Zinc sulphate, alone or with lime, has proved effective and safe when applied by spraying. Zinc oxide to control mottle-leaf is held by the California Station to offer promise for combination with insecticides. Fertilizer tests by this station failed to give satisfactory results unless zinc had been applied to the trees. While all forms of zinc tried produced improvement in tree condition, dusts were not so efficient as sprays.

Little leaf and rosette, closely related troubles of deciduous fruit trees common in the Pacific Coast States, have been studied by the California Station, which has done much to throw light on the effects and methods of prevention. Laboratory experiments with a variety of crops, including annuals, and with a variety of soils, fertilizers, and mineral treatments, confirmed the conclusion that zinc deficiency is clearly involved, but there was indication that micro-organisms in the soil may also be associated, at least in some instances, in producing the toxic effects noted. Application of zinc continued to correct the difficulty, but other treatments, like the growing of alfalfa in affected soil, also appeared to overcome the power of the soil to induce the disease.

In order that certain mineral-deficiency diseases might be distinguished from others, the California Station investigated and reported on the types of symptoms caused by manganese, sulphate, and magnesium starvation in citrus trees. Boron deficiency was found by the same station to induce effects like the perplexing psorosis or scaly bark disease in citrus. Through boron administration to ailing apple trees in the Champlain Valley, the New York (Cornell) Station obtained evidence that internal cork, a widespread difficulty in the fruit, as well as rosette and a certain type of dieback in the trees, are probably associated with boron deficiency.

The disappearance of psorosis from certain trees in orange and grapefruit groves and its development on additional healthy trees during a period of years were reported by the Florida Station, which also obtained evidence that the barkscraping control method is effective except where the disease has apparently become systemic.

The probability that excess chlorine in irrigation water is associated with the ringneck disease of avocado fruits and the way toward its prevention are indicated from evidence secured by the California Station.

Virus diseases are a serious menace to peaches in certain regions. The Maynard plum was shown by the Colorado Station to be capable of harboring the virus of the destructive peach mosaic without production of symptoms, a discovery important for its control. The mysterious "X" disease, reported first from the State about 1933, has been shown by the Connecticut (State) Station to be of probable virus origin and to be carried to peach from nearby diseased chokecherries, whose removal appears to check further spread.

For the *Coryneum* shot hole disease of peaches and almonds, so destructive on the Pacific coast, the California Station has found bordeaux mixture better than other fungicides, with indications that addition of a dormant-type oil emulsion may improve its control of twig infection in peaches. Life-history studies made it possible to work out a more effective spray program for the disease. Fall

sprayings with bordeaux mixture and lime-sulphur also proved effective under California conditions for controlling the widespread peach leaf curl disease (*Taphrina*) when applied shortly before the buds began to swell. A home-made wettable sulphur that has given good results in peach orchards for disease control has been developed by the Virginia Station. The benefit of zinc sulphate in reducing arsenical injury on peaches, although it is inefficient as a fungicide, has been demonstrated by 7 years of experimental work by the Illinois Station. The efficiency and safety of a number of spray materials for the control of cherry leaf spot (*Coccomyces*) have been compared by the Michigan Station. This disease seriously affects the crop in bad seasons and greatly reduces subsequent orchard vigor and yield. Although lime-sulphur proved less injurious than bordeaux mixture, it resulted in some dropping of leaves and was less effective than three new types of commercial copper sprays, which gave excellent control without serious injury or leaf drop and are therefore recommended for further field trial.

Root knot nematode is probably more prevalent and persistent throughout the South than any other parasite of peach trees, but it may eventually become a very unimportant peach pest in view of the encouraging results with introduced nematode-resistant stocks. The California Station found several deciduous fruit rootstocks apparently quite immune and a seedling of the Shalil peach, originally introduced by the Department of Agriculture (B. P. I.) from India, very resistant. However, Yunnan peach stocks have appeared in recent tests to run even higher for resistance than Shalil, and some other types have also shown up well.

Insect pests of orchard trees.—Without control practices for the codling moth or common apple worm, developed by entomologists and now in general use, commercial production of apples would very likely have become a thing of the past in some of the important apple-producing States. Lead arsenate spray has been found the most generally effective means of control, but important considerations have made necessary extensive studies on substitutes for lead arsenate, on means of obtaining superior spray coverage, on improved methods for spray residue removal, and on the use of supplementary control measures. Such studies are being actively pursued by many experiment stations. Codling moth trapping studies conducted for 10 years by the Washington Station show, among other factors influencing the pest, that worm damage is largely correlated with initial infestation in individual orchards. New evidence of the development of codling moth strains in sprayed orchards that are more difficult to control by arsenicals than those in unsprayed plantings has been contributed by the Virginia Station.

That codling moth may be reduced in the orchard by means of light traps has been demonstrated by the New York (Cornell) Station in cooperation with the Department of Agriculture (B. E. & P. Q.), the tests reported giving a control equal to two cover sprays of lead arsenate. Working with the electrocution type of trap, the New York State Station showed that many insects are strongly attracted to blue or violet lights but are not sensitive to yellow flames from oil or tallow. Bait traps were found by the New Mexico Station to be at least doubled in effectiveness by the use of mercury-

vapor lights, and the most satisfactory baits tried consisted of fermenting cane sirup and ethyl oxyhydrate. The effectiveness of bait traps was greatly increased by the Pennsylvania Station through suspending them beneath 75-watt lights, while the use of anethole with the bait increased the catch of egg-laying codling moths more than five times. Beta naphthol-treated tree bands were found by the Virginia Station to be successful in destroying worms seeking to pupate, and the Pennsylvania Station, from tests with bands treated in various ways, concludes that their supplementary use yields gratifying results at moderate cost where spraying without banding has failed.

For increasing the effective load of arsenical on the fruit as a means of improving the protection against codling moth entrance the Washington Station has developed the use of so-called inverted spray mixtures. These have become popularly known as dynamite sprays and consist of lead arsenate mixed in the spray tank to which, in the proper manner and proportion, mineral oil, oleic acid, and either triethanolamine or ammonia have been added. Two years' trial in one of the most severely infected orchards showed that it is possible to keep down the worms with the use of first-brood applications alone applied prior to the first of July. That serious difficulty in removing the residue will follow if these sprays are applied at a later time was also clearly shown.

Various spreading and sticking agents for use with lead arsenate sprays have been tested by the New York State Station. The most satisfactory results were obtained with soybean flour and hydrated lime which produced a heavy, even coating, resulting in best worm control and easy residue removal.

In heavily infested orchards in the southern part of the State, the New Jersey Station found summer oil emulsion with lead arsenate to give improved worm control. That good protection in southern Indiana can be obtained by thorough and heavy sprayings applied frequently prior to June 20, which cleans up the first-brood worms with no further spraying, is indicated by tests at the Indiana Station.

In reference to spray residue removal the Oregon Station, a pioneer in solving this serious problem, has found that heavily sprayed apples which cannot be cleaned by the usual hydrochloric acid or sodium silicate solvent may be washed effectively in acid supplemented with petroleum oil and that wetting or degumming agents properly used increase the solvent action of the acid. Had no practical washing process been developed, there would probably be no chance that apple and pear growers in the Pacific Northwest could market their fruit under existing Federal regulations. The hydrochloric acid bath is shown by the New Jersey Station to be successful and practicable also for removing residues from cherries.

In the testing of possible substitutes for lead arsenate that will control codling moth and involve no toxic-residue problem, steady progress has been made. Although it appears difficult to find anything quite as effective and as noninjurious to foliage or fruit as lead arsenate, the Michigan Station concluded that calcium and zinc arsenates combined with proper correctives and certain stickers will closely approximate lead arsenate performance under Michigan conditions, while six seasons' tests showed that when used intelligently,

and frequently enough, the summer oil-nicotine sulphate spray will afford good worm protection.

In tests of insecticides by the Washington Station results comparing favorably with those from lead arsenate were obtained from calcium arsenate provided certain mixtures were added to prevent injury and insure adequate coverage, but its use only experimentally is advised for the present. Calcium arsenate was found by the New Jersey Station to be distinctly inferior to lead arsenate in codling moth control with equal quantities of arsenical deposit, due perhaps to the inferior physical properties of the former. Of available substitutes, calcium arsenate used judiciously and certain of the fixed nicotine sprays have met with most success in tests by the New York State Station. An iron arsenate-calcium arsenate combination used by the Missouri Station on Ben Davis apples failed to control the worms and also caused severe injury. On the other hand, Lloyd's reagent with nicotine sulphate, used with a sticker, gave approximately as good control as lead arsenate. Neither phenothiazine nor oil-orthonicotine, when used throughout the season by the Ohio Station proved satisfactory for codling moth, but it was found that control of this insect and particularly of plum curculio was greatly improved where lead arsenate was used in the first (calyx) worm spray followed by either of these materials for later sprays. For the last three sprays of the standard six-spray schedule, phenodithiazine and oil emulsions containing derris were the best substitutes for lead arsenate of any materials tested by the New Mexico Station. Fixed nicotine was found by the New Jersey Station to be more powerful against codling moth than the usual lead arsenate-lime milk spray, but it did not equal, in general, the lead arsenate-oil combinations. The oil-nicotine sulphate spray was shown by the Michigan Station to be of sufficient value on certain varieties of apples for use where growers are not equipped for arsenate removal.

The apple curculio, an important pest of apples in certain sections, was studied for 5 years by the New York State Station in relation to its wild crab and hawthorn hosts, its life history (involving a single brood each year), and the insects which parasitize it. The information thus obtained and similar facts collected by the Wisconsin Station should aid in perfecting control measures. The latter institution found parasites of considerable importance, learned that lead arsenate is of some effect in laboratory tests, and obtained indications that a repellent at the critical spring period might prove beneficial.

The apple leafhopper was found by the Virginia Station to cause less damage as the hairiness of apple leaves increased. This finding may be of much use in connection with other crops affected by this pest (e. g., potatoes, peanuts, and alfalfa).

The pear midge, an undesirable alien which frequently destroys up to half the crop in New York orchards, not only damages infested fruits, as shown by the New York State Station, but also causes uninfested fruits in the same cluster to be shed. Best protection was afforded by nicotine sulphate sprays timed to destroy the adults before they could lay eggs.

The oriental fruit moth, an introduction from Japan causing damage to a number of different kinds of fruits, has been shown by the Virginia Station to be very resistant to insecticides and to be worse

where apple and peach orchards are adjacent. The best means of reducing the severe damage from this pest sustained by the quince industry in western New York was found by the New York State Station to consist of applications of strong lead arsenate with sticker or spreader or of summer oil with nicotine repeated at frequent enough intervals throughout the summer to keep the fruit constantly protected.

The peach borer is a destroyer of peach trees throughout the country which the Illinois Station found possible to control by paradichlorobenzene dissolved in oil, but application of this insecticide in crystal form proved cheaper and hence more practicable. For the lesser peach borer, which works on the branches rather than at the base of the trunk, best control without tree injury was obtained by using paradichlorobenzene in a commercial oil at double the strength required for the other borer.

For control of the cherry casebearer, a troublesome insect in Wisconsin, both copper- and sulphur-containing fungicides were found by the Wisconsin Station to reduce the number of eggs laid.

The mealy plum aphid of world-wide distribution is a problem on the Pacific coast, and the California Station has sought points of attack in its life history which might result in successful control. Valuable toward this end is the finding that eight different stages are to be distinguished in its life and that migrant forms do not go from plum to plum but leave the plum and go to cattail or reeds early in the season, traveling up to distances of 30 miles and returning to plums in the fall.

The *Latania* scale, probably the most serious pest of avocados in California, can be killed by properly fumigating the boxes of fruit with hydrocyanic acid, according to tests by the California Station. This station also discovered that pyrethrum, although exceedingly effective for the control of many insects, does not work effectively on California red scale and that dependence must be placed on other measures.

SMALL-FRUIT PESTS AND DISEASES

Ups and downs in the small-fruit industry have probably been due as much to the incursions of various insect pests and plant diseases as to any other production factor. The established small-fruit areas that have successfully survived have been able to do so largely by growing resistant varieties or by using protective measures developed by Government and experiment station workers whose activities are illustrated below.

Diseases of small fruits.—Virus diseases have proved to be among the most serious problems confronting the raspberry industry. This is true in New York State where, after a 5-year study of virus diseases in plantings of black raspberry, the State station reported that wild red raspberries are practically symptomless carriers of mosaic viruses that damage the blackcap berries and also maintain populations of the principal aphid carrier (*Amphorophora rubi*), which effectively spreads the mosaics to black raspberry plantings. The station therefore recommends that all wild red raspberries within at least 1,000 feet be destroyed. In addition, the use of resistant varieties or of healthy stock with systematic removal of any plants becoming diseased is ad-

vised. Delayed leafing, found to be an early symptom of green mosaic in black raspberries, should greatly aid in detecting affected plants for removal. Common methods of eradicating wild brambles were effective when properly managed, as were various chemicals. Wild brambles other than the red raspberry were found to be of little consequence as virus carriers.

Verticillium wilt of black raspberries, studied by the Oregon Station, is believed to have been a primary factor in causing certain western Oregon districts to discontinue growing this crop. Tests indicated that infection may travel 10 feet from plant to plant in 3 years. All varieties of black and purple raspberries proved susceptible. The Cuthbert red raspberry proved very resistant, as did the blackberries and some Asiatic species of brambles. Many common weeds are known carriers. Rotations (3- or 4-year) with nonsusceptible intervening crops proved effective against the fungus, and stock from disease-free nurseries is also recommended.

The rosette disease of blackberries and dewberries (*Cercosporella rubi*) was shown by the Louisiana Station to be identical with the double blossom disease of blackberries and dewberries. The causal fungus overwinters in the buds, and the infection period was shown to be limited in Louisiana to a short period in spring. This unexpected discovery and related facts have cleared the way for successful control of this disease which had long baffled southern growers. Bordeaux mixture was found effective when applied so as to protect new buds throughout the spring.

Studies of roots from diseased strawberries, coupled with inoculation tests by the Utah Station, indicated that three widespread species of soil fungi, and perhaps a fourth, are capable of causing the typical black root rot which has been considered a serious cause of dying out in many parts of the country.

Chlorosis or leaf yellowing, frequently injuring cultivated blueberries, the Massachusetts Station found traceable to a deficiency of available iron. Injection of iron compounds into the plants restored the green color and in some instances an application of ammonium sulphate to the soil was also effective.

Small-fruit insects.—Adults of the blueberry maggot in cultivated blueberry plantations were killed by the New Jersey Station through dusting from an airplane or autogiro with 10 to 15 pounds of derris dust (5-percent rotenone) to the acre, applied about June 27–30 and July 7–10.

For leafhopper control on grapes sprays containing nicotine with a spreader were found by the Michigan Station to afford control and to be most effective when applied at the time of hatching of the eggs and before the young insects developed wings.

A curculionid weevil was found by the California Station seriously infesting the buds of grapevines in one locality. The buds of grape cuttings were eaten as rapidly as they grew out, and many of the cuttings ceased to grow. Use of Tanglefoot gave fairly satisfactory results in control.

Derris is apparently very effective in controlling the cranberry fruitworm, an insect pest of great economic importance to the industry, according to studies by the Massachusetts Station.

The blackberry mite, according to the Oregon Station, is no longer a scourge to growers of the State, since control methods employing lime-sulphur and oil sprays developed by the station have proved effective in handling this pest. Studies of the currant fruitfly, a serious pest on both currants and gooseberries in Oregon, as elsewhere, are summarized, and application of a poison-bait spray of lead arsenate, cheap molasses, and water is recommended as the most satisfactory treatment. The Oregon Station has also developed poison baits to protect strawberries against root weevil, which formerly threatened to destroy the industry.

The strawberry weevil, the Virginia Truck Station finds, is serious on the Eastern Shore of Virginia where some fields are said to have had as high as 75 percent of the buds cut by the insects laying eggs. Sulphur-lead arsenate, lime-lead arsenate, and sulphur-derris dusts gave effective weevil protection in the Virginia tests. Since the common red spider is also frequently serious in this area, the sulphur-lead arsenate dust is preferred because it gives protection against this pest. The sulphur-derris dust, however, may be used to eliminate the danger from an arsenical residue in fields where early berries have set.

DISEASES AND PESTS OF ORNAMENTAL PLANTS

The experiment stations have not neglected their responsibility to florists and nurserymen, who have had to face problems as important as those confronting the farmer and fruit grower.

Diseases of ornamentals.—Successful control of the common and damaging fungus black spot disease of roses through the use every 2 weeks of a spray containing 1 part of red copper oxide to 1,600 parts of water was reported by the New York State Station. Addition of cottonseed-oil emulsion at every third application was found to avoid foliage injury to which certain varieties are subject. The common insecticides were compatible with this copper spray. Dieback disease of roses due to another fungus (*Diplodia*) was controlled by the Texas Station through weekly removal of bloom buds failing to open followed by dusting with a mixture of sulphur, monohydrated copper sulphate, and paris green (9–1–1).

A bacterial blight of iris leaves, possibly of wide distribution, was reported by the New York (Cornell) Station. It was found to be a wound parasite of the sap-conducting system favored by warm, wet weather and to occur on various species of iris. In experiments with a mosaic disease of iris, transmissible artificially, plants inoculated in one growing season did not develop symptoms until the following season, according to the Oregon Station cooperating with the Department of Agriculture (B. P. I.). Two out of five species of aphids tested were shown to be carriers of the virus. Cross inoculations between Dutch and Spanish varieties were readily successful, but no hosts were found outside the iris genus. These facts pave the way for the development of methods of preventing the continued spread of this insidious disease.

The virus-induced spotted wilt disease of sweet pea was proved by the California Station to be identical with the world-wide spotted wilt of tomato, tobacco, and many other plants transmitted by

thrips. Control of this sweet pea disease appeared to lie in the isolation of plantings from other susceptible crops or in protection against the migrations of infective thrips. An abnormal distortion of growth (fasciation) in winter-flowering sweet peas and chysanthemums was shown by the Ohio Station to be due to a new species of bacterium. Experimentally, it induced malformations in 10 varieties of sweet pea and also in garden pea, petunia, geranium, tobacco, and gypsophila. With this information in hand, measures can be taken to combat the trouble.

Penicillium rot is a serious disease of lily bulbs introduced into the United States from Japan and other countries. The New York (Cornell) Station found that it can be effectively prevented by adding calcium hypochlorite powder to the packing soil.

Damage under greenhouse conditions from a canker and gall disease of gardenia due to a fungus of the *Phomopsis* type, believed to be the same as that in California and Ohio, is reported by the Western Washington Station. Control measures were suggested. A serious foliage yellowing of gardenias under glass was found by the Massachusetts Station to be due to improper assimilation of iron which could be corrected by the use of sulphur in small amounts and of ammonia sources of nitrogen.

Rhododendron wilt, shown by the New Jersey Station to be due to a fungus (*Phytophthora cambivora*), is said to be the most serious disease of young rhododendrons known. *Rhododendron ponticum*, widely used as an under stock for grafting, is especially susceptible, but the station reported that control may be effected by careful daily roguing of field frames, by careful management of plants, of soil, and of light, and by allowing infested soil to freeze outdoors as deeply as possible.

Two physiologic races of the snapdragon rust fungus were distinguished by the California Station. One of them attacks common rust-susceptible snapdragons but not the recently developed rust-resistant strains. The second race, found in the coastal districts of the State, attacks severely all susceptible and resistant varieties tested.

A leaf spot of primula due to a new species of bacterium was found by the California Station. Among 27 species and varieties, 21 proved susceptible.

The root knot nematode, one of the most widespread and damaging soil parasites, attacks numerous flowering plants. Of some 80 annuals tested by the Florida Station, 26 proved resistant to infestation.

The most satisfactory way to eliminate root knot from the soil is to grow plants (especially *Crotalaria spectabilis*) on which the nematodes cannot live and to keep the land free from other vegetation.

Insect pests of ornamentals.—Fumigants and poison dips were found by the New York State Station to be effective in destroying gladiolus thrips overwintering in stored corms. Treatment of the corms in storage or at planting time with cyanide, naphthalene, or corrosive sublimate is advised. For mites on lily bulbs the New York (Cornell) Station obtained satisfactory control by adding calcium hypochlorite powder to the packing soil.

The life history, destructive effects, and control of a new species of webworm attacking *Cotoneaster* were studied by the Oregon Station. It was readily controlled by various contact or stomach poison sprays, provided thorough coverage and proper timing were given.

Control of the western rose curculio, one of the most destructive enemies of wild and cultivated roses in the State, was studied by the Colorado Station. Carbon disulphide emulsion treatment of the soil killed overwintering larvae, dusting with calcium arsenate killed the adults, and picking all the injured buds and destroying them gave protection the following year.

DISEASES AND PESTS OF FOREST AND SHADE TREES

Diseases of trees.—Such experiences as the total extinction of the American chestnut by the chestnut blight, the salvation of millions of acres of pines from the blister rust at a cost of millions of dollars, the long fight against the gypsy moth, and the present heroic efforts to eradicate the recently introduced Dutch elm disease are sufficient to indicate the major importance of pests and diseases of trees to our forests, parks, and home surroundings.

Studies of the Dutch elm disease, largely directed to determining its distribution and behavior as a guide to eventual eradication, have been instituted by various State stations in addition to work by the Department of Agriculture (B. P. I. and B. E. & P. Q.).

In the early stages of a fungus (*Verticillium*) wilt disease of maples described by the Massachusetts Station, fertilization, with ample watering when necessary, resulted in good growth and disappearance of the symptoms. Removal of badly affected trees is advised, and also avoidance of the susceptible Norway maple, hard maple, American elm, and Japanese barberry in replanting.

The biology of a wood-destroying fungus (*Pleurotus corticatus*) found in fire-scarred and decayed hardwood trees in the Mississippi Delta section was reported on by the Minnesota Station, with evidence as to the possibility of its dissemination by termites and other insects. In studying the effects of chemicals on the rate of decay in wood, this station found that low concentrations of either arsenic trioxide or zinc chloride not only failed to check but actually stimulated decay by two kinds of wood-destroying fungi. This was not true for two other species, which succumbed to low concentrations of arsenic. Thus lumber treatments must now be tested with a wide range of fungi. The probable importance of the amount and availability of organic nitrogenous materials in wood as a factor in determining its rate of decay was indicated by other Minnesota studies.

A hitherto undescribed fungus (*Cephalosporium*) canker of balsam fir in natural stands in Minnesota and Wisconsin was investigated by the Minnesota Station. Following artificial inoculation, cankers up to 12 inches long developed within a year. A widespread and destructive fungus (*Cytospora*) canker of spruces was studied by the Massachusetts Station, which reported on its history, distribution, symptoms, and course of development. Once established, the disease slowly destroys the lower limbs, finally killing the tree. It is considered the most serious disease of Colorado and Norway spruces in the State. Additional information on the fungi associated

with tree cankers was contributed by the Iowa Station. A gall disease of Douglas fir was shown by the California Station to be due to a new species of bacterium. Actual contact of the parasite with the wood tissues appeared essential for infection, and a scale insect (*Chermes cooleyi*) was suggested as the probable carrier.

The interrelationships of insects and fungi in the deterioration of felled red (Norway) pine logs during the second and third years after cutting were studied further by the Minnesota Station. The fungus (*Peniophora gigantea*) primarily responsible for decay of the sapwood and some of the heartwood is probably airborne, but two species of wood-boring beetles (*Monochamus*) in the logs appeared to hasten the heartwood decay by their tunneling.

Insect pests of forest and shade trees.—An outbreak of a tortrix moth among 200 acres of young transplants of white, Scotch, red, and jack pine, in which the new growth on about 95 percent of the white pine was killed before the infestation was discovered has been reported on by the Michigan Station. The caterpillars were readily killed by contact or stomach poisons, but a nicotine soap spray was considered best.

The spruce aphid, attacking principally Norway and white spruces but to some extent other species, and the Sitka aphid, occurring largely on Colorado blue spruce, which it definitely injures, and also on Douglas fir during a part of its life history, were studied by the New York State Station. The Sitka aphid has also recently proved to be a pest in some commercial nurseries. Both aphids were effectively controlled by one thorough insecticidal spray applied during the dormant season to kill the immature overwintering aphids.

The biology, seasonal history, natural enemies, and control of the juniper webworm, which appeared as an injurious insect in Maryland in 1931 and has now spread rather generally over the State, becoming perhaps the most injurious insect attacking common juniper, has been studied by the Maryland Station. Lead arsenate spray without spreader proved an efficient remedy, as did undiluted lead or calcium arsenate dusts if applied during summer or early fall.

A compendium on the native elm bark beetle (*Hylurgopinus rufipes*), an insect capable of spreading the dreaded Dutch elm disease, was contributed by the Connecticut (State) Station, covering the history, distribution, morphology, and nomenclature of this insect and giving detailed descriptions of its various stages. A saturated solution of paradichlorobenzene and raw linseed oil applied in early June as a paint to the trunks of elm trees larger than 1½ inches in diameter safely prevented injury by the elm borer, according to tests by the North Dakota Station in a State where successful tree establishment is of major importance.

Soaking bamboo canes for 8 weeks in water greatly reduced the damage produced by powder-post beetles and increased the growth of roots and sprouts, as shown by the Puerto Rico Station in cooperation with the Department of Agriculture (B. E. & P. Q.). This is an important discovery for the Tropics where bamboo is one of the most generally useful of plant products.

PESTS AND DISEASES AFFECTING MISCELLANEOUS PLANTS

Some diseases and pests are confined rather definitely to one particular plant species, many are limited to one group or to related

groups of plants, whereas still others are more or less omnivorous in their parasitic or food-plant relationships. Research on certain omnivorous plant enemies has already been mentioned in the preceding sections because of their destructiveness to one of the individual crops or plant groups considered there. Other examples of research on general or miscellaneous diseases and pests are cited below.

Miscellanous plant diseases.—The *Phymatotrichum omnivorum* root rot has already been partially discussed under cotton, but reference must be made to the Texas Station report of a study covering a period of years on the resistance or susceptibility of a large number of plant species. This very serious and baffling disease was found to affect a multitude of hosts, including not only many of the crop plants widely grown in root rot areas, but also many native weeds, shrubs and trees, and some less common plants. The nonselective habit of this fungus parasite, together with its ability to persist in once infested soils, greatly increases the complexity of the control problem in certain southern crop areas, but the knowledge obtained as to possible sources of infection should materially aid in its solution. As a further important contribution, a member of the Nebraska Station staff helped map out in advance the areas of soil infestation by the root rot fungus in the shelterbelt zone of southern Oklahoma and Texas with the object of avoiding such areas in planting trees or of utilizing species known to be resistant. The approximate limits of root rot infestation were found to be south of 34° N. latitude and east of the one hundredth meridian. In the main, root rot was much more pronounced in the better agricultural soils and in the valleys. Repeated observations indicated that when the disease is found in the head waters of a stream, it usually is distributed throughout the drainage basin, its incidence increasing at the lower levels.

The southern root rot fungus, *Sclerotium rolfsii*, is a virulent parasite attacking a wide variety of hosts, including many of our most important crop plants. It reproduces by means of tiny, hard fungus kernels (sclerotia) that remain dormant in the soil until conditions favorable for growth and infection appear. The California Station found that 8 to 28 percent of the sclerotia consumed in the rations of sheep and cattle were not digested and could later grow. Thus livestock fed on diseased plants may spread the disease into uninfested fields.

Fungus infections known as damping-off often seriously menace the seedlings of a large number of plants ranging from young nursery trees to vegetable and truck crops, both in the field and under glass. After 2 years' tests by the New York State Station in commercial greenhouses, a red copper oxide spray (1 to 50) was recommended as a valuable supplement to seed treatments with red copper oxide, zinc oxide, or organic mercurials (according to the crop) to prevent damping-off after the seedlings emerge.

Root knot nematodes, as plant enemies, have already been mentioned. The Florida Station recently presented important data on the conditions necessary for their growth, on their distribution and methods of spread, their common host plants, including fruit trees and ornamentals, and their wild hosts, with lists showing relative susceptibilities. Control methods helpful in various situations were

set forth, including starvation by rotation with resistant crops, drowning, and dry heat, steam, hot water, and chemical treatments. The number of nematode generations was found to increase with warmer temperatures, control thus becoming particularly difficult in the South.

In its work on diseases of hops, the New York State Station showed red copper oxide spray to be as effective as bordeaux mixture in controlling the erratic and destructive downy mildew without the stunting effects of the latter spray.

"Slip-down" of hops, first recognized in 1935 as a virus disease though having occurred in New York for at least 30 years, was found to reduce the yields of affected plants to less than a fourth of the normal. The hop aphid was shown to be capable of disseminating this virus. An important part of the control program undertaken consists in building up a virus-free stock from which growers may make replacements and start new yards.

Miscellaneous insect pests.—The seriousness of the introduced Japanese beetle as an enemy of many of our orchard, ornamental, and crop plants is too well known to require emphasis. Studies directed toward its eradication, the restriction of its spread, and its control in established areas are being carried out by the Department of Agriculture (B. E. & P. Q.) and various eastern experiment stations. Of the various repellents tested, the Delaware Station found the best protection to be afforded by tetramethyl thiuram disulphide in a 40-percent rosin-residue emulsion. Good results were also obtained by derris in a 50-percent emulsion with rosin sticker, and by a number of other repellents.

Studies of the grasshopper scourge in the past few years, according to the North Dakota Station, have done much to dispel a belief held by many that the breaking up and cultivation of large areas in the Northwest would reduce the extent to which this insect group damages field agriculture. At least one of the most migratory and widespread species (*Melanoplus mexicanus*) was found to lay its eggs as readily in cultivated areas as in native sod. Other economically important species were shown to prefer laying their eggs in soddy places. These facts must be recognized in dealing with the national grasshopper problem.

In a study of the relative susceptibility of various strains of corn to grasshopper damage, the Kansas Station found pronounced differences. All the open-pollinated varieties adapted to Kansas conditions showed a fairly low degree of injury. In two groups of top crosses, those from Kansas hybrids were well toward the top in grasshopper resistance. In a group of 52 hybrids, all of those from Kansas inbreds showed low injury as compared with hybrids from out-of-State inbreds. It is thus suggested that natural selection has had a part in building up inherited resistance to grasshopper injury in varieties which have been grown for a considerable time under conditions of frequent infestation. The Kansas Station reports also that under proper conditions of temperature and moisture, a relatively small number of grasshoppers may cause great damage to grain crops by clipping the heads or eating the developing kernels. Similarly, a relatively small number can destroy the pasture grass seed crop. The station describes the injury to some 10 species of grasses

and gives an account of the grasshoppers responsible for the damage, of which 15 species are listed. It is concluded that serious damage of this sort results from efforts by the insects to obtain enough moisture in very dry weather. Another angle of the problem was presented by the Arizona Station, which claims that only five or six of the true grasshopper species occurring in Arizona and in Colorado should be classed as injurious to crops and scarcely more than a dozen others should be listed as offering serious danger to the grasses of the range. A study of their food relations led to the conclusion that many kinds of grasshoppers are strikingly beneficial in that they help to check the worst weeds that would otherwise overrun the overgrazed ranges. Although in 1937 grasshoppers damaged Colorado crops valued at about $3,500,000 in the worst outbreak since 1880, intensive cooperative poisoning operations by the Colorado Station, the Department of Agriculture (B. E. & P. Q.), and more than 21,000 farmers were estimated to have saved other crops worth $9,000,000, more than 31,000,000 pounds of bait having been used.

In feeding measured doses of poison to grasshoppers and silkworms, the Iowa Station found wide differences in the relative toxicity of lead arsenate and sodium fluosilicate. Whereas the two were about equally poisonous to the silkworm, the fluosilicate proved to be over 19 times as toxic as the arsenate to the grasshoppers tested. Such facts indicate a need for individual tests with each pest and insecticide.

A study of the environal relations and control of the universal garden-crop pests known as cutworms was conducted by the Tennessee Station. Moths were most abundant in late August and early September. Data from light traps indicated that some species are attracted, others repelled, and still others are not affected by their surroundings. Numerous tests indicated that half a pound of sodium fluosilicate mixed with 25 pounds of wheat bran is more toxic to cutworms than paris green or other arsenicals. A manual dealing with 570 Pennsylvania species of noctuid moths, including cutworms, armyworms, etc., and referring to the life history and food plants if known, has been published by the Pennsylvania Station.

A study of the omnivorous leaf tier or strawberry fruitworm has been reported by the Oregon Station. This dangerous European pest was first found in the United States in 1929 in Oregon, tunneling into strawberries. Its known hosts include 29 common plants, and its typical injuries to strawberry, Dutch iris, flax, peas, wheat, hops, filbert, clover, vetch, alfalfa, and wild flowers are described. Five species of insect parasites were observed attacking this imported plant enemy, thus leading to the hope that natural enemies may eventually aid in its economic control.

June beetles (white grubs) are widespread, injurious, and difficult to deal with. In tests of stomach poisons against adult female June beetles (*Phyllophaga lanceolata*), the Iowa Station found the calcium arsenate sample to produce very little effect and sodium fluosilicate also seemed to be of low toxicity, but zinc arsenite apparently possessed a relatively high toxic value. In tests with both females and males of another species (*P. implicata*), the males were killed in every instance more easily than the females, though the females always ate the poisons a little more readily. It thus proved

necessary to determine the minimum killing value of each poison for each sex. Of the five poisons thus tested, paris green proved to be the most toxic to females, whereas paris green and cuprous cyanide were equally toxic to males. On the other hand, sodium fluosilicate was least toxic to both females and males.

Control of the periodical cicada, which appeared in Michigan in 1936, was attempted by the Michigan Station, three common insecticides being tested. It was found practical to knock the adults off the trees with either thiocyanate (1 to 150) or pyrethrum (1 to 150) and to kill those surviving after 10 to 12 hours with a blow torch. Where this treatment was not feasible, a nicotine-soap spray gave a satisfactory kill. A nicotine-summer oil spray successfully killed the eggs laid in the twigs.

In an attempt to control the common red spider mites which seriously infest a number of greenhouse crops, the Illinois Station found the great variations in their susceptibility to certain sprays to be closely correlated with the species of plant infested. The materials used included ammonium polysulphide, two organic thiocyanates, and a proprietary derivative of cyclohexylamine, all of which proved effective and safe when applied to certain plants. Karaya gum was found to be a highly efficient agent in increasing the toxicity of red spider sprays.

H. P. Barss and
Frederick V. Rand.

ANIMAL PRODUCTION AND PRODUCTS

Each year it becomes increasingly evident that genuine progress in the field of animal production must be based on a wider knowledge of the fundamental principles underlying the genetic and physiological processes of the different kinds of animals. Scientific research in the agricultural experiment stations is showing a definite trend toward the establishment of new facts of a basic nature. The comparative feeding and management studies which have occupied so prominent a place in the field in the past have been widely supplemented or supplanted by investigations of a more fundamental character. The mode of inheritance of individual characters and of combinations of characters that go to make up animals of a desirable type are receiving more attention at the present time than at any previous period in the history of the experiment stations. The role of the hormones or endocrine secretions in regulating many vital processes and productive functions of the animal body is assuming increased importance, thus greatly stimulating research in this field. The proper feeding of the organism from the embryonic stage through its period of economic usefulness still presents many unsolved problems. Much current research is centering on the requirements for and the functions of the vitamins and the minor or "trace" mineral elements which, though required in very small amounts, are indispensable in animal nutrition. The effects of different feeds and methods of feeding upon the animal products consumed by man is of major importance from the consumer's standpoint and experiments are being conducted toward solving many such problems. The consumer demand for new and improved animal products is a constant reminder of the need of more factual material along this line.

Examples of the recent findings in these several fields of research are given in the following pages.

ANIMAL GENETICS AND PHYSIOLOGY

GENETICS

Progress in livestock breeding has been retarded by a lack of suitable and accurate standards of performance as well as by a lack of knowledge of many genetic principles.

Increased interest is being devoted to the establishment of accurate "yardsticks" and to the selection and development of breeding stock possessing the ability to transmit superior characteristics to their progeny. The newer trends in animal breeding are based on attempts to assemble combinations of desirable characters without necessarily having definite knowledge of their mode of inheritance. By taking advantage of the findings with small animals, plants, insects, and to some extent larger animals, it has been possible to develop principles leading to an understanding of the inheritance of characters.

Genetic studies with swine.—In an attempt to investigate what is really happening in the Danish system of testing swine, the Iowa Station made a study of the pedigrees of the breeding animals used in a number of the breeding centers and the variance of the progeny. The station concluded from this investigation that less than half of the individual variance in the characteristics studied could be attributed to genetic effects. The breeding methods followed have served the Danish farmers well, and evidence indicated that by following these practices distinct beneficial changes may be expected in the population for at least a few more generations.

Improved characters in sheep.—The South Dakota Station reported progress in its attempts to produce a breed of sheep without tails, thereby avoiding the necessity of docking lambs. A strain of good conformation and desirable wool characters with practically no tail was produced. A large percentage of the progeny from this line mated with Southdown ewes had relatively short tails.

The New Hampshire Station continued its attempt to establish a flock of sheep with four functional nipples. At present about 75 percent of the ewe flock have three to five functional nipples.

Scurs in cattle.—Although the mode of inheritance of the polled character in cattle has been well established as dominant to the horned condition, the inheritance of scurs has not been clearly worked out. The Kansas Station attempted an analysis of this condition based on the records of the Galloway and Holstein-Friesian cattle crosses at the Alaska Station. When both the scurred and polled factors are present, males have scurs but females are polled. If the factor for horns is present in either sex, it is expressed to the exclusion of the factor for scurs.

Estimating weight of dairy cattle.—A cooperative study by the Missouri and Nebraska Stations involving individual weight and measurements of over 10,000 dairy cattle of different breeds and ages gave evidence that the relationships between chest girth and live weight are sufficiently constant to permit the practical estimation of weight from chest girth measurements.

Selecting poultry breeding stock.—The use of trap-nest records as a basis for selection of desirable poultry breeding stock is a practice of recognized merit. The New Jersey Station concluded that trap-nest records for either the winter period or the summer-fall period could be employed with confidence in the selection of breeding stock. The combined winter and summer-fall records were highly valuable in this respect, probably being fully as accurate for that purpose as the record of exact egg-production performance over the full year. The saving of labor by following such a procedure is apparent.

Inheritance of egg production.—An investigation by the New York (Cornell) Station of the quality of eggs produced by different hens indicated that the character determining the condition of firm albumin was inherited and transmitted from dam to daughter. It was not possible, however, to effectively fix in the offspring by selection characters relating to the percentage of outer thin albumin, percentage of firm albumin, and yolk index.

The inheritance of high and low persistency of egg production in Rhode Island Red fowls was established at the Massachusetts Station. In crosses there was evidence of the dominance of high persistency. In selecting breeding stock for high persistency, it is suggested that the standards be set well above a 270-day minimum to eliminate birds possessing the low persistency character.

Size inheritance in poultry.—Differences in early growth rate of various breeds of hatchery chicks frequently is a matter of concern to the purchaser. Studies at the Oklahoma Station of the first 8 weeks' growth of different breeds of fowls showed that the variations observed were not necessarily associated with the mature weight, since it was evident that less than half of the variance observed in the 8 weeks' weights was due to hereditary factors. The growth rate of crosses of White Rocks and Buff Orpingtons corresponded closely with that of the more rapidly growing parent.

A study at the California Station of the relationship between the measurements and weights of different portions of the body of Plymouth Rock, Minorca, and Bantam fowls indicated that basic genetic factors existed for the size interrelation of parts but that these did not necessarily control the ultimate size. Evidently Bantams possess growth-retarding factors affecting not only total body size but also the relative rate of growth of parts. During the period from 2 to 14 days of age the concentration of glutathione, a substance associated with rapidity of growth of the whole body was greater in Barred Plymouth Rock chicks than in the lighter weight Leghorn chicks.

The California Station found shank length to be a better measure of size than body weight in crosses between different strains of White Leghorns. In the first cross the shank length was intermediate but approached the longer boned parent.

Lethal factor in the fowl.—A new mutation in the fowl which proved to be lethal was described by the California Station. This is the eighth lethal factor which has been reported for the fowl. The condition expressed itself as an abnormality of the upper jaw, which prevented hatching because of the inability of the embryo to pip the eggshell. A morphologically similar abnormality has been observed in pheasants, partridges, and turkeys.

PHYSIOLOGY

Reproduction in sheep.—A better knowledge and understanding of ovulation and time of fertilization in the ewe is of practical importance in breeding operations. In consequence, in cooperation with the Department of Agriculture (B. A. I.), the Missouri Station investigated the oestrus cycles of over 300 ewes of different breeding and determined that the period during which the ram was accepted ranged from 3 to 73 hours, with an average duration of 29 hours. Investigation by direct observation of the ovaries showed that ovulation occurred from 12 to 41 hours after the onset of heat. Correlating these results with studies at the Massachusetts Station, which indicated that the speed of travel of the spermatozoa in the genital tract of the ewe was 12.4 millimeters per minute, it would appear that the optimum time for breeding a ewe is near the end of the heat period.

Seasonal and individual variations in sperm production of rams permitted to mate at will were measured by the Missouri Station. Increased numbers of abnormal sperm were found during the hot season, but during the breeding season, frequency of service had no effect on sperm morphology. Rams varied greatly with respect to the frequency with which they would mate. They also varied in the sperm concentration of the semen in successive matings.

Ovulation in the fowl.—In order to gain more knowledge regarding the mechanism of egg production and the tendency of hens to lay eggs in clutches, observations were made on 33 normal ovulations in hens at the Kansas Station, from which it was concluded that ovulation was due, at least in part, to pressure resulting from prolonged tension of the muscle fibers in the follicular membrane. The stimuli for such tension were not determined. The interval between successive eggs was found to average 26.3 hours, and the interval from the time an egg was laid until the next ovulation occurred averaged 32.2 minutes. Ovulation seldom occurred in the afternoon and the day of nonlaying was a result of delayed ovulation.

In a study of the relationship of the time of day and season of laying to the hatchability of eggs, the Massachusetts Station found that the hatchability increased as the laying season progressed for mature hens but not for pullets. Differences in the fertility, mortality, and hatchability of fertile eggs laid at different times of the day were not significant.

An intimate relation of light to ovulation in hens and turkeys was demonstrated by the Kansas Station. Turkey hens subjected to artificial morning light were induced to lay at 242 days of age, as contrasted with about 307 days of age for similarly handled birds not subjected to the light treatment. Further investigations showed that white and red lights were responsible for this effect, whereas blue light failed to exert any influence. Hens subjected to continuous artificial lighting laid at any hour of the day or night. Hens kept in darkness during the day and subjected to artificial lights during the night laid only at night. These changes in lighting conditions were not immediately reflected in the hens' laying reaction but required about 60 hours to have their full effect. The results indicate that the hens' reaction to light is entirely psychological.

Sexual maturity in cockerels.—It is of practical importance to know the age at which cockerels reach sexual maturity. Studies with Barred Plymouth Rock cockerels by the Indiana Station showed the presence of mature sperm at 20 weeks of age, and such cockerels mated with hens fertilized eggs at from 16 to 32 weeks of age. It was therefore considered that poultrymen might find it advisable to use young, early hatched males in the breeding pens during the early fall months to replace old males which are likely to be molting and not giving satisfactory fertility.

Physiology of lactation.—The intricate interrelationship of various hormones to mammary gland development and milk secretion has been demonstrated through extensive investigations by the Missouri Station.

The pituitary gland plays a dominant role at all stages of udder growth and development. The function of the pituitary in milk secretion is even more complex. A hormone, lactogen, secreted by this tiny gland exerts a direct influence in initiating the secretory function of the udder and in maintaining the activity of the secreting cells, while the secretions of this gland appear to regulate the activity of the adrenal and thyroid glands and carbohydrate metabolism in the body, all of which are intimately related to the initiation and maintenance of lactation.

It has been possible to increase the secretion of milk by injections of the lactogenic hormone, indicating that the amount of secretion of this hormone by dairy cows may be one of the important reasons for the variation in milk-producing ability.

In studies at the New York (Cornell) Station, injections of a pituitary hormone, lactogen, in goats induced milk secretion, and if injected late in lactation, the milk yield was increased. The normal decline in lactation was considered due to the senility of the mammary gland, but rapid decline resulted from an insufficient quantity of lactogen which could be supplied experimentally with good results.

Attempts to isolate specific hormones have not been entirely successful. In studies of the effect of acid and alkaline extracts of fresh and dried sheep pituitary on mammary gland growth and secretion in rabbits, the New York (Cornell) Station found that different hormones were responsible for gland growth while others were needed to induce secretion. Alkaline extracts of sheep pituitaries caused growth in the mammary gland and milk secretion in rabbits, whereas acid extracts had no effect on mammary growth but caused lactation within 4 days when the gland was previously developed.

Artificial insemination of cattle.—The Nebraska Station reports that it has used artificial insemination with dairy cattle during the past 2 years with excellent results. Fifty percent of the services have resulted in conceptions and 74 percent of all conceptions occurred from a single service. Important advantages of artificial insemination are the ability to use a bull on a larger number of cows and over a much wider geographical area and the prevention of spread of certain infections.

Disease resistance.—Selection at the Iowa Station for eight generations of mice from survivors of inoculations with the organism causing mouse typhoid showed that the mortality in successive gen-

erations continued to decrease. Crosses of susceptible stock with resistant stock produced F_1 progeny with a total mortality of 17 percent when inoculated with the causative organism. This was nearly as low as the mortality of the resistant stock, suggesting the dominance of genetic factors for resistance. Observed differences between the blood picture of disease-resistant birds and those that have and have not recovered from diseases were suggested by the Wisconsin Station as possible leads toward determination of the relative susceptibility to disease and differentiation from those which would be most likely to prove resistant.

NUTRITION

The statement has frequently been made by livestock production specialists that a great majority of our farm livestock are better bred than fed. Studies to determine the nutritive requirements of animals and the productive value and nutritive shortcomings of feedstuffs continues to occupy a prominent place in the livestock research program.

Nutritive value of roughages.—Roughages, including all grazing crops, hays, and silages, are of extreme importance in animal production not only because they generally constitute the most economical source of nutrients for many classes of animals but also because they are indispensable from the standpoint of supplying certain nutritive essentials not present in the grains and byproducts feeds. Recent movements to bring about an improved land-utilization program, involving a great increase in the acreage of grazing and forage crops, has focused attention upon the maximum use of such crops for animal feeding and has stimulated research activity along this line.

Composition of hays.—In the young stages, the chemical composition of the dry matter of wheat, oats, and barley hays was found by the Washington Station to be practically identical with that of alfalfa and sweetclover, with the exception of calcium and phosphorus. As cereals approached maturity, the stem-leaf-head ratio was shown to be a fairly reliable index of their nutritive value. There was a close association of crude fiber with stems; of total ash and calcium with leaves; and of phosphorus, crude protein, and nitrogen-free extract with heads. In general, the medium-dough stage of kernel maturity was most desirable for hay for these cereals. Any benefits from increased digestibility past this stage was offset by shattering of kernels, leaf loss, leaching, and general plant deterioration.

Vitamins in roughages.—Carotene, the precursor of vitamin A, is generally abundant in green forage, while the percentage retained in stored roughages depends largely upon methods of preservation. Numerous pasture plants studied by the Kansas Station, including various common grasses, cereals, and alfalfa, showed relatively high carotene values in early summer, but with rather wide variations. During the hot months of midsummer, the carotene content tended to decrease markedly. After the fall rains most of the plants reestablished their carotene content on practically the same plane as the early summer values. Notable exceptions were found in some plants which were practically devoid of carotene in the fall.

Leaves of baled alfalfa stored in a hay barn from August to November were found by the Arizona Station to contain less vitamin A than the leaves of freshly baled alfalfa. The rate of loss was greatly reduced during the winter months but after 12 months in storage the alfalfa contained only 25 percent as much vitamin A as had been found in the fresh alfalfa. Dehydrated alfalfa leaf meal stored in a gunny sack in a heated, well-lighted room, at the Ohio Station, lost 80 percent of its carotene value in 6 months. The Colorado Station showed that the loss or inactivation of vitamin A in alfalfa hay resulted from the usual practice of curing and stacking, exposure to ultraviolet light in the presence of moisture, and storage of alfalfa meal in cloth sacks. Vitamin A conservation in alfalfa was enhanced by curing indoors, curing by rapid artificial drying, or by crushing and rapid drying, storage in the bale, and storage of alfalfa meal in paper bags.

Carotene destruction in alfalfa hay cured in the swath or windrow was found by the Michigan Station to be more rapid than in cock-cured samples during the early stages of drying. At the time the hays were sufficiently cured for barn storage, the loss was greatest in the swath-cured hay but approximately equal in the windrow and cock-cured lots.

The vitamin B complex is present in green forage. Alfalfa, clover, and timothy hays cut at different times and cured under different conditions were found by the Ohio Station to contain significantly more vitamin G than vitamin B_1. These factors in the hay decreased as the plants matured and, in general, were correlated with leafiness, greenness, and protein content of the plant. Field curing without rain did not affect the vitamin G content, but rain removed as much as 50 percent of this factor. Bluegrass, rye, wheat, and timothy all compared favorably with clover or alfalfa in vitamin G content when cut at similar stages of maturity. These results were essentially confirmed by the Colorado Station.

Legume silage.—Nonleguminous plants were found by the New York (Cornell) Station to average very much higher in water-soluble carbohydrates than the legumes, which probably explains why the latter crop has so frequently failed to produce a silage of satisfactory quality. Legume silages of superior quality were produced by the addition of fermentable sugars such as corn sugar or molasses, or by the addition of mineral acids and mixtures of organic and mineral acids in amounts sufficient to increase the acidity to a point where microbial activity was inhibited.

Legume silage prepared by the so-called A. I. V. process, i. e., with suitable additions of hydrochloric and sulphuric acids, the Wisconsin Station found, retained completely the carotene content of the forage, and cows fed such silage in winter produced milk containing 40 percent more vitamin A than cows receiving a well-balanced winter ration containing alfalfa hay and corn silage. The addition of 50 to 60 pounds of molasses per ton of ensiled green timothy more efficiently preserved the carotene content than did additions of 40 pounds of molasses, as indicated by trials at the New Jersey Station. The addition of 80 pounds of molasses per ton of alfalfa or other legume silages also resulted in satisfactory carotene and protein preservation.

Treatment of legumes with acid in silage making was found by the Ohio Station to be the only method which gave full assurance of preserving the carotene content of the crop nearly intact.

Chemical changes in A. I. V. silage.—Alfalfa ensiled by the A. I. V. method at the Wisconsin Station after a period of storage had made large gains in amino and water-soluble nitrogen, but only small increases in ammonia nitrogen. The content of volatile acids, ethyl alcohol, and lactic acid indicated that micro-organisms similar to those present in corn silage were active. A large number of micro-organisms were present at the various stages of the storage period. Alfalfa ensiled without acid showed enormous numbers of bacteria and produced large quantities of ammonia and butyric acid, indicative of excessive deterioration.

Minerals in nutrition.—Recent experiments have yielded much new information on the requirements for and the effects of various minerals in the animal diet. The necessity of cobalt in the animal diet was first discovered in Australia. The deficiency of this element in the soil and plants in certain sections of this country have only recently been recognized. The Florida Station has described a type of malnutrition occurring in calves fed a diet of locally grown Natal grass hay, shelled corn, and dried skim milk. This condition was corrected by the addition of a cobalt supplement but was apparently aggravated by the use of ferric ammonium citrate or copper sulphate in the diet. It was impossible to raise calves to a weight of over 450 pounds on the deficient diet.

Symptoms resulting from deficiencies of either potassium or magnesium in the animal diet have been described by the Alabama Station. The lack of either exerted a marked growth-retarding effect, with potassium shortage resulting in characteristic pathological conditions of the heart and abdominal organs and magnesium deficiency causing marked skin disorders and extreme irritability.

The calcium content of growing rats has been found by the Illinois Station to be dependent not only on the calcium content of the diet but also on the rate of growth, which is largely determined by the rate of food consumption. An inverse relationship between rate of growth and calcium content was attributed to a tendency for rapid growth to be associated with slow calcification of the bones and a high ratio of soft tissue to skeletal tissue. Very low levels of calcium in the diet retarded growth not only during the consumption of such a diet but also during a subsequent period of adequate calcium supply.

Deficiencies of sodium, phosphorus, or iron and copper in the rat ration were found by the Pennsylvania Station not to affect significantly the digestibility of rations, but that deficiencies of sodium or of iron and copper reduced the utilization of the protein and food energy of the diet and retarded the rate of growth. In all cases body storage of these elements was greater at the higher levels of intake.

Minerals for beef cattle.—Beef heifers continued to gain in weight and to maintain the inorganic phosphorus content of the blood at about the initial level throughout the course of a trial at the California Station when the phosphorus intake was maintained at a level of 0.4 percent of the feed. On the other hand, heifers on a diet containing only 0.13 percent of phosphorus ceased to grow after 6

months. Animals were able to maintain their body weight over a 1-year period when the phosphorus intake was reduced to 0.09 percent, but finally lost weight when the phosphorus was further reduced to 0.068 percent. The phosphorus deficiency did not affect the digestibility, or metabolizability of the food energy, or the level of fasting katabolism, but decreased the efficiency of energy utilization and also the efficiency of the food protein for sparing body protein.

On a range known to be deficient in phosphorus but fairly high in calcium, the New Mexico Station showed that mineral mixtures, consisting of salt and various sources of phosphorus, offered free choice, were equally efficient in supplementing the range forage for heifers. The lower level of phosphorus intake was apparently adequate to meet the animals' needs, while higher levels failed to stimulate more rapid gain. In a field test at the Wyoming Station, breeding cows receiving bonemeal had a higher percentage of calves at weaning time, had less calving difficulty, and dropped stronger calves than did a control lot receiving no bonemeal. At the same station, a winter ration of native hay and sunflower silage furnished sufficient calcium and phosphorus for cows of beef breeds so that the addition of minerals to the ration produced no measurable improvement.

Minerals for swine.—The Illinois Station concluded that in the presence of adequate vitamin D and calcium, 0.3 to 0.35 percent of phosphorus in a ration composed predominantly of corn was adequate for maximum growth and bone development. Under such conditions, the only mineral supplement needed is salt.

The minimum phosphorus intake which will allow normal growth and development in swine is, according to the Kansas Station, from 0.27 to 0.30 percent of the ration, which is equivalent to about 6.5 grams of phosphorus daily per 100 pounds of live weight in young pigs and about 4 grams daily per 100 pounds of live weight for 200-pound pigs.

Additions of 0.5 percent calcium carbonate (ground limestone) to a very low calcium diet containing 0.5 percent phosphorus was found by the Ohio Station to be adequate for growing pigs. A continuous low calcium intake caused a pronounced subnormal calcium content in the blood serum of swine and eventually resulted in calcium tetany, according to the California Station.

Digestion and energy utilization of feeds.—Extensive studies of the digestibility of rations by steers, milking cows, and sheep at the Pennsylvania Station gave evidence that each group of animals digests rations most efficiently when fed at a maintenance level. In general, sheep digested the experimental rations more efficiently than cows, and it is concluded that the published average coefficients of digestibility of feeding stuffs for ruminants which in the main had been determined with sheep at low planes of nutrition are several percent too high to apply to the full-fed milk cow.

The feed energy losses by fermentation were found by the Missouri Station to be equivalent to about 25 percent of the maintenance requirement of ruminants, and on the basis of these experiments the station has computed the true respiratory quotients of certain feedstuffs and has contrasted these with the apparent respiratory quotients formerly published. The effects of the level of protein intake on feed utilization has also been studied by the Missouri Station. Digestibility

of food constituents, except protein, was practically identical for the high and low protein diets. Heat production averaged about 3.5 percent higher on the high protein diet, while the higher respiratory quotient on the low protein diet indicated a greater fat storage than for the high protein diet. Carcass analyses showed that animals on high protein rations stored more water, protein, and ash, and less energy per unit of gain than the animals on the low protein intake which stored more fat. The net utilization of energy for body gain in all animals was adjudged the same.

Utilization of vitamin A by dairy cows.—Carotene and vitamin A content of individual butter samples determined spectrophotometrically at the Texas Station indicated that some cows have greater power than others to secrete vitamin A and carotene into the butter. When two cows previously depleted of vitamin A reserve were placed upon pasture, the vitamin A potency of the butter increased from 12 to 40 or 50 units per gram within 3 days. The vitamin A potency of butter is closely related to vitamin A potency of the feed and the period the cow has been receiving it.

When cows were fed green rye, the Kansas Station found that of the carotene and vitamin A ingested less than 1 percent was recovered in the butter as carotene and as vitamin A. When excessive amounts of carotene were fed, the ratio of carotene to vitamin A in the butter became rather constant at about one to two. The Pennsylvania Station found it difficult, if not impossible, to affect the nutrition of the animal seriously by feeding a low carotene roughage. It also demonstrated that the vitamin A potency of the milk from the different breeds of dairy cattle under uniform feeding conditions was approximately equal per gram of butterfat contained in the milk, indicating that breed difference in vitamin A potency of the milk is proportional to the percent of milk fat characteristic for the breed.

Vitamin A requirements of cattle, sheep, and swine.—Results obtained at the California Station have supported the idea that the vitamin A requirement of animals is directly related to their body weight since it was found that the minimum requirements of cattle, sheep, and swine was from 25 to 30 micrograms of carotene daily or from 6 to 8 micrograms of vitamin A daily per kilogram of body weight for each species.

Vitamin A and fertility in sheep.—The California Station found that when ewes were in good condition and had large stores of vitamin A in their livers, a low vitamin A intake for 5 months, including the breeding season, did not significantly reduce the number of lambs born as compared with control animals receiving vitamin A above minimum requirements during the breeding season. Limiting the protein intake over a 4-month period, including the breeding season, had little effect on the number of lambs produced. When ewe lambs were restricted to a low vitamin A intake, they were not depleted of vitamin A stores at breeding time, but continuation of the deficient diet during gestation led to depletion of vitamin A storage, and most of the lambs born were weak and died soon after birth. When ewes were depleted of vitamin A to a point where night blindness occurred at breeding time, about 65 percent of the ewes conceived, but gestation was unsuccessful and all of the lambs were born dead or died within 24 hours.

Vitamin requirements and sources for poultry.—Poultry are particularly susceptible to nutritive deficiencies in the ration.

The levels of carotene or vitamin A required in satisfactory poultry rations has been investigated by a number of stations. The Ohio, Washington, and New York (Cornell) Stations agree in their findings that approximately 150 units of vitamin A per 100 grams of ration are required for young growing chicks. The Ohio Station showed that carotene was effectively utilized by the chick as a source of vitamin A and that 50 to 100 micrograms of carotene per 100 grams of ration was adequate to prevent symptoms of vitamin A deficiency. A more intensive rate of carotene feeding was required to cure the symptoms after chicks had been allowed to become depleted of vitamin A storage. Trials at the Texas Station indicated that chicks produced from hens receiving a low vitamin A intake suffered a much higher rate of mortality than those from hens amply supplied with this factor. Liberal feeding of vitamin A to the chicks did not overcome the effects of such a deficiency in the hens' diet.

Dehydrated alfalfa meal proved a satisfactory source of carotene in the ration of chicks at the Washington Station and it was found that chicks lived and grew on vitamin A-deficient diets in proportion to the amount of this factor in the diet of the parent stock. Both the New Jersey and Washington Stations found that maximum egg production and hatchability was attained when approximately 500 units of vitamin A was included per 100 grams of the laying ration. The New Jersey Station also concluded that the commercial production of certified eggs high in vitamin A is not feasible because of the inefficiency with which hens transfer vitamin A from feed to eggs.

The Ohio Station finds that poultry has a definite requirement for riboflavine, an isolated component of the vitamin B complex, and concludes that the beneficial effects of feeding dried whey, yeast, and liver meal to poultry are largely due to the flavine content of these products. Dried buttermilk proved a more potent source of flavine than either dried whey or dried skim milk, in trials at the Washington Station.

A new dietary-deficiency disease in chicks characterized by lesions or eroded areas in the gizzard lining has been reported by the California Station. These symptoms are prevented by a fat-soluble factor present in fresh or dried leafy material and in wheat bran. It is tentatively designated as the anti-gizzard erosion factor and is not identical with any of the known vitamins.

The vitamin D requirements of young chicks was found by the Texas Station to be largely dependent upon the calcium present in the ration and that with optimum calcium levels as little as 3.6 units of vitamin D per 100 grams of ration will give normal growth and bone calcification in birds confined in the absence of sunlight to 12 weeks of age.

The Pennsylvania and Ohio Stations agree in showing that laying hens confined in the absence of sunlight have a high requirement for vitamin D to sustain high egg production, eggshell quality, and hatchability of eggs. The Ohio Station confirmed previous findings of the Wisconsin Station that equivalent units of vitamin D supplied in irradiated cholesterol and in cod-liver oil were equally

effective in poultry nutrition and found that the vitamin D potency of egg yolk and the vitamin D storage in chicks was dependent upon the level of vitamin D intake of the hen.

Salmon fish meal fed at either 2.9- or 5.7-percent levels in an all-mash ration for chicks at the Washington Station gave complete protection against rickets. The same mixed ration after 1 year's storage still afforded protection at the same levels of feeding, but when the fish meal was stored separately for 1 year and then incorporated in the mix it gave protection at the 5.7-percent but failed at the 2.9-percent level, suggesting that the basal ration acted as an antioxidant in preventing loss of vitamin D in the salmon meal during storage.

A new nutritional disease of the chick embryo.—The Connecticut (Storrs) Station, in cooperation with the Department of Agriculture, has described an abnormality in the chick embryo characterized by disproportionate stunting of certain skeletal tissues, particularly the long bones of the legs and wings. The abnormal embryos usually die during the third week of incubation although they occasionally hatch and the few that have been raised lost all abnormal appearance in the course of 10 weeks. This condition is of nutritional origin and can be prevented by supplying to the parent stock factors present in wheat germ, liver, or whey. Permitting birds access to direct sunlight and green range increased the utilization of these factors. The Kentucky Station has described a similar type of abnormality in chick embryos which was entirely prevented by increasing the manganese content of the hens' ration. Also when eggs from hens on a manganese-deficient diet received direct injections of 0.03 milligrams of manganese before incubation, normal chicks were hatched.

Perosis of poultry.—Perosis, or slipped tendon, in chicks has reached serious proportions in commercial poultry production. Additions of steamed bonemeal and ground limestone to the basal diet of chicks, at the New York (Cornell) Station, at varying levels and in different proportions have all resulted in a high percentage of perosis in chicks, and additions of chemically pure salts of calcium and phosphorus aggravate this condition to about the same extent as bonemeal. Additions of small amounts of manganese to the diet proved very effective in preventing perosis even at relatively high levels of calcium and phosphorus, while additions of iron, aluminum, and zinc apparently exerted some beneficial effect. The Texas Station reported that the constituents of wheat gray shorts, which prevented perosis in chicks, was confined to one or more mineral constituents of the ash. The Louisiana Station found that when blackstrap molasses replaced rice bran at a 10-percent level in the chick ration a very high percentage of perosis results.

Adding ether, alcohol, and water extracts of the various components of a basal ration at the Oklahoma Station did not further aggravate the occurrence of perosis. A drinking solution consisting of the water extract of rice bran largely prevented the occurrence of defective legs and resulted in larger, smoother, better-colored legs and accelerated growth. The ash of rice bran also prevented perosis. There was evidence of a correlation between the manganese content of a ration and its curative properties, but the protective action of

certain rations having no manganese additions indicated that other factors may be involved.

Animal and vegetable protein.—The Nebraska Station found that the percentage rate of gain and the gain per gram of nitrogen fed was greater in a lot of chicks which received a basal ration supplemented with a mixture of animal proteins than in a similar lot receiving their protein supplements from vegetable sources. There was no difference between the lots with respect to calcium and phosphorus contents in the chick bodies, but the nitrogen content of the group receiving animal protein was somewhat greater.

Amino acids for chicks.—In an effort to explain differences in growth-promoting properties of certain feeds or combinations of feeds, the Wisconsin Station showed that arginine is an essential amino acid for chicks which is not supplied at optimum level in ordinary grain rations during rapid growth. The New Jersey Station has demonstrated that tryptophane, histidine, and cystine are all essential amino acids for the growth of chicks.

New byproducts feeds.—The California Station has demonstrated through feeding and digestion trials that perilla meal and babassu meal are both palatable feeds relatively high in digestible protein and total digestible nutrients, that hempseed meal, while of fair feeding value, was quite unpalatable, and that kapok meal was so unpalatable as to preclude its use as a feedstuff.

BEEF CATTLE

Proper stocking of ranges.—The New Mexico Station concludes from its studies that, in general, the weight of a mature cow, the weight of the calf, and the percentage of calf crop are the best indicators of the plane of nutrition on which they have been raised. Their variation from the ideal was usually a measure of over or under stocking of the area upon which they grazed. Even on ranches stocked in such a way that there is an abundance of forage, there may be a deficiency of minerals or protein or possibly of vitamins during the winter or the dry season of the year. Such deficiencies prevent the animals grazing upon these ranges from being up to normal in weight and production.

Beet tops for fattening steers.—The Colorado Station has found dried whole beet tops to be very satisfactory as a partial substitute for alfalfa hay in steer-feeding tests. However, feed costs per unit of gain were somewhat greater when tops were fed. When used to replace all the alfalfa in the ration, beet tops caused digestive disturbances at from 100 to 120 days' feeding, resulting in retarded rate and increased cost of gain. The slight improvement in feed value due to grinding the tops did not justify the extra cost involved. Beet-top silage, while undergoing very little spoilage, was not highly palatable and cost more than the feed it replaced. Steers fed stacked beet tops made relatively slow gains at a rather high feed cost per unit of gain.

Creep feeding of calves.—In cooperative experiments with the Department of Agriculture (B. A. I.), the West Virginia Station showed that creep feeding high-quality calves on a grain mixture while they were still running with their dams on good pasture made it possible to market the calves 3 to 4 months earlier and on about

half as much grain as was required to fatten a similar group of calves that did not have any grain until after they had been weaned. Creep feeding made it possible to market calves in the fall while calves not so fed had to be carried through the winter months, thus effecting savings both in time and in feed.

Native grass for finishing cattle.—Steers full-fed on pasture at the North Platte, Nebr., Substation and finished in dry lot made practically the same gains and were of equal market desirability as those full-fed throughout the fattening period in dry lot. Animals receiving a limited amount of corn and those receiving no grain on pasture made definitely cheaper gains than those receiving a full feed and there was no apparent difference in the market desirability of the different lots.

The fattening of native v. grade cattle.—A comparison of the production and quality of meat from native and grade Hereford yearling cattle by the North Carolina Station, in cooperation with the Department (B. A. I.), indicate that the native animals made slower gains at all stages of the trial, that they required considerably more grain and roughage per unit of gain, and at prevailing feed prices cost $1.31 more per hundredweight of gain than the grade Herefords. The grade cattle dressed somewhat higher, were fatter, and produced a higher percentage of edible meat and a lower percentage of bone. Meat from the grade carcasses also proved more tender but no significant differences in palatability were observed.

Milo grain in the fattening ration.—Results obtained by the Texas Station in cooperation with the Department (B. A. I. and B. P. I.) indicated that the slight advantage in the feeding value of threshed milo grain over the unthreshed milo head was insufficient to justify the cost of threshing but that grinding of either the threshed grain or whole heads was economical in steer feeding.

Fat in cattle carcasses.—Periodic killings of heifer and steer calves at the end of each of four intervals of feeding at the Michigan Station showed that there was an increase in fat content of the dressed carcass from approximately 13 to 33 percent. The percentage of fat in the most highly finished animals was about two and one-half times as large as that in cattle having the lowest degree of finish. In every case a greater gain and consequently a heavier weight was necessary among the steers than among the heifers to produce a similar degree of fatness. There was a general trend toward a greater net-energy requirement in the ration for increased fatness in cattle. The fattest cattle produced 53 pounds more chilled carcass per 1,000 pounds live weight than did the least fat cattle. A marked increase in the ratio of edible meat to bone accompanied the increase in fat, while at the same time the firmness of lean and marbling increased but there was no material change in the color of the lean or fat. As the degree of finish improved there was a progressive improvement in the intensity and desirability of flavor of lean and in quality and quantity of juice, but tenderness showed little or no change.

As a result of studies on the relation of fat to the palatability of beef, the Kansas Station concluded that the degree of finish or fatness appeared to be associated with palatability. An increasing degree of finish rendered more intense the properties of tenderness, juiciness, and flavor. There was a point, however, beyond which increased

increments of fat did not improve the palatability. The California Station showed that the yellow color that often occurs in beef is caused by deposition of carotene. The color may also result from an unbalanced nutrition of the animals, but no sure remedy for the condition is now known.

"Black cutter" beef.—From a study of causes of "black cutter" beef, the California Station concluded that since it had not been able to produce dark or black cutting beef under experimental conditions, and since it apparently appears sporadically without any definite relation to age, feed, origin, or handling of the cattle, it is logical to look for a hereditary basis for the trouble. The phosphorus intake of steers at the Kansas Station did not influence the color of the muscle or fat tissue of the beef produced, and did not have any direct influence on the tenderness of the beef.

See also page 129.

DAIRY CATTLE AND DAIRYING

Animal protein for dairy cattle.—A comparison of steam-dried and flame-dried menhaden fish meal by the Maryland Station showed that these two meals were apparently equal in palatability for yearling heifers. Slightly more rapid growth resulted from the flame-dried meal ration, although differences were hardly significant. No significant differences were noted by the Ohio Station in the growth rate of groups of heifers fed either whitefish meal or linseed meal as protein supplements. Also, the differences in milk and fat production during the first lactation could not be attributed to the method of feeding. While the birth weight of calves born in the two groups was approximately the same, the calves of the fish-meal group were more vigorous and the iodine contents of their thyroid glands were higher than the calves of the linseed-meal group. While the two feeds compared very favorably, the fish meal was of special value in supplying iodine, which, in certain sections, may be a rather important factor in determining the producing ability, general health, and reproducing capacity of dairy animals.

The use of dried blood as a protein concentrate in place of soybean-oil meal and cottonseed meal in the dairy ration proved satisfactory in trials at the Massachusetts Station. The dried-blood mixture proved palatable, maintained the level of milk production, and exerted no unfavorable influence on the composition or flavor of the milk.

Roughage for dairy cattle.—When timothy hay was properly supplemented with a grain ration containing sufficient protein and with adequate quantities of calcium, phosphorus, and irradiated yeast, the Virginia Station found that milk and butterfat were produced as efficiently as when the same quantities of alfalfa hay and grain with no minerals were fed. Peanut hay was found by the North Carolina Station to be superior to soybean hay in milk and butterfat production and increase in body weight. Rape and kale were economical and efficient feeds for dairy cows in studies at the Oregon Station, and made good substitutes for silage. Both feeds, however, flavored milk and care was needed in their feeding so as not to produce off-flavor milk. The Washington Station maintained three groups of cows on roughage alone for 3 years. All groups were on pasture

during the summer months. In winter one group received hay, another group silage made from the same material as the hay, and the third group a combination of hay and silage. Good production was maintained throughout the experiment, demonstrating the value of home-grown roughage for dairy cows.

Succulent feeds.—Comparison of dried-roughage rations with those containing both dry and succulent roughages, at both the Vermont and Minnesota Stations, indicated that no significant advantage pertained to either type of ration. Apparently when cows have free access to drinking water, the value of the ration is measured primarily by its digestible-nutrient content and not by its water content. Feeding trials at the Oklahoma Station indicated that mung beans have considerable merit as a silage crop under conditions which are not favorable for the production of crops usually grown for this purpose. The South Carolina Station reported on the successful use of corn silage, mixed corn and soybean silage, and soybean silage prepared with additions of molasses as sole sources of roughage in the winter ration for milking cows. The Washington Station has described a method of preparing stack silage in which the spoilage losses were only slightly greater than in an upright silo and by which the cost of silage production is materially reduced.

Color of milk.—The intensity of yellow color in market milk is being extensively used as a selling point for this commodity. Mean monthly color values obtained at the New Jersey Station indicated that milk is relatively high in color from May to October and relatively low in color the rest of the year. The lowest color values observed were during the 2 months just prior to the time cows were turned on pasture. Feeding 12 pounds of dehydrated alfalfa that had been stored for 6 months or 5 ounces of a carotene concentrate per cow daily during the late winter months had no effect on increasing the yellow color of the milk. The continued feeding of a ration of long field-cured hay, beet pulp, and grain resulted in a lower color in milk than was obtained from a dehydrated hay and silage ration. The gradual decline in milk yield near the end of lactation was accompanied by the gradual increase in percentage of fat and in color.

Vitamin C in milk.—The Kansas Station noted significant variations in the vitamin C content of morning and evening milk and between day to day milk. The level of production, age of the animals, and access to green feed were found to have only a slight effect on this vitamin content, while season of the year, the individuality and breed of the cow, and the stage of production appeared to be the most important factors causing variations in the vitamin C content of fresh milk from well-fed cows.

It is generally considered that pasteurization greatly reduces the vitamin C content of milk. The New York (Cornell) Station found that milk which did not come in contact with copper or copper-bearing alloys at any stage of the handling process could be pasteurized at 145° F. for 30 minutes and still maintain essentially the same ascorbic acid content as raw milk of the same age. However, traces of copper in milk caused a marked decrease of ascorbic acid under the holder method of pasteurization but had little effect when milk was flash pasteurized at 170°. This condition is attributed to the

fact that a temperature of 145° for 30 minutes only slightly weakened the enzyme causing oxidation of ascorbic acid whereas heating to 170°, even momentarily, almost totally destroyed it.

Seasonal variations in the vitamin D content of milk.—The Michigan Station finds that the antirachitic potency of normal milk may vary as much as 900 percent over a 2-year period. The potency reaches a maximum from June to September, and, beginning with October, declines rapidly to a minimum in February. Vitamin D values ranged from 4.8 to 43.8 U. S. P. units per quart of Guernsey milk, and from 3.1 to 27.7 U. S. P. units per quart of Holstein milk. The amount of exposure of the cows to sunlight appeared to be the most important factor in contributing to the variability of the vitamin D content. The vitamin D contained in dairy feeds appeared to contribute very little to the potency of the milk. Cows had little or no opportunity to store vitamin D during lactation under ordinary dairy-management conditions.

Flavor of milk.—Milk is readily susceptible to off-flavor development from numerous causes, thus necessitating extreme care in the production and distribution of this product. Oxidized or tallowy flavor is one of the most common flavor defects. The Wisconsin, New Jersey, Pennsylvania, and West Virginia Stations have all obtained evidence to show that milk produced during the summer months is less susceptible to the development of oxidized flavors than winter milk due to certain factors present in the fresh green feed. The addition of 1 quart of either tomato or lemon juice or 0.5 gram of pure crystalline ascorbic acid per animal daily to the rations of cows at the West Virginia Station greatly reduced the susceptibility of their milk to oxidized flavor development. Exposure of milk and milk products to sunlight at the Pennsylvania Station ordinarily resulted in the development of off flavors designated either as burnt or tallowy. These defects appeared to be distinct flavor changes, the former predominating in low-fat products and the latter in high-fat products. Paraffin paper milk bottles offered considerably more protection to skim milk, whole milk, and buttermilk against the development of burnt flavor than was afforded by clear glass bottles. However, paper bottles were no protection to whole milk or cream against tallowy flavors caused by sunlight, but blue- and green-colored paper bottles or blue or green cellophane wrappers on paper bottles retarded the development of both burnt and tallowy flavors.

Results of studies by the Wisconsin Station indicated that the activated flavor of irradiated milk was distinctly different from the commonly described oxidized flavor. The activated flavor originated in or was closely associated with the protein fraction of the milk. However, this flavor may be due to absorption of such flavors by fat.

The California Station has demonstrated that feed flavors due to alfalfa-hay silage or pasture can be greatly minimized or entirely prevented by withholding such feeds for a few hours prior to the milking period. The South Dakota Station reported that the feeding of tankage to milking cows even to the extent of 50 percent of the concentrate ration had no perceptible effect on the flavor of milk.

Preventing flavor defects in ice cream.—By adding from 0.5 to 0.7 percent of commercially prepared oat flour, the Pennsylvania Station delayed or prevented the onset of oxidized flavor in ice

cream for several weeks in most cases. Additions of 0.5 to 2 percent of oat flour in fresh cream before being frozen afforded definite protection against oxidized flavor in ice-cream mixes employing such cream as the sole source of butterfat. The body score of ice cream was favorably affected when oat flour was added at either the 0.5- or 0.7-percent level, but higher levels unduly increased the viscosity of the mix.

Butter quality.—In an attempt to develop new methods for determining the quality of cream, the South Dakota Station found that the percentage of total nitrogen occurring as amino nitrogen increased as the quality of cream decreased and, in general, cream and butter containing the higher percentage of amino nitrogen gave lower butter scores. However, classification of churnings on the basis of amino nitrogen content of cream alone failed to determine satisfactory butter grades. Apparently the amino nitrogen content may be an aid in cream grading only when used in combination with flavor and acidity tests.

Crumbly butter.—Crumbly body, commonly found in butter made during the winter months, was found by the Minnesota Station to be associated with, although not directly dependent upon, the composition of the butterfat. This factor in the score of winter butter may be improved by avoiding excessive cooling of cream, churning at a temperature not lower than necessary to secure exhaustive churning, and washing the butter with water at from 40° to 50° F.

The direct addition of commercial oat flour to cream before pasteurization and churning, at the Pennsylvania Station, materially retarded the oxidative deterioration in butter stored at 40° to 45° F. over 6- to 8-week periods. However, the resulting sediment in the butter, and a positive test for starch, made this method of using oat flour undesirable. The addition of aqueous extracts of oat flour, equivalent to 1 percent of the oat flour, offered similar protection to butter with none of the undesirable effects noted from the flour. Butter stored in temperatures above 0° in parchment treated with oat flour, at both the Pennsylvania and Oklahoma Stations, developed flavor defects on the surface much less rapidly than butter stored in ordinary parchment.

Cheese production.—Observations made by the Wisconsin Station indicated that salt rapidly penetrated the outer layer of brick cheese, but about 8 weeks elapsed before the salt concentration was uniform throughout the cheese. As the salt content of any given portion of the cheese increased, the moisture content decreased, but the increased salt failed to account for the marked moisture decrease. Dry salting was as effective but less uniform in results than brine salting. Excessive salting caused hard curdy body, white color, slow ripening, loss of yield, and delayed lactose fermentation, while low salt encouraged abnormal fermentation associated with weak body and open texture.

Adding 0.75 percent of cane sugar to milled Cheddar cheese curd just before salting, the New York State Station found, reduced moisture content and improved the body and flavor of the ripened cheese as compared with control lots from the same vats which did not receive sugar. The results suggested that sugaring curds in making Cheddar cheese could well be introduced as a standard procedure because of moisture reduction and quality improvement.

A satisfactory method for the manufacture of a Roquefort type of cheese (blue cheese) from homogenized cow's milk has been introduced by the Iowa Station, and the station has also isolated the chemical constituent which is primarily responsible for the characteristic flavor in this type of cheese.

Based on tests of a number of mineral salts which may be used as emulsifiers in the preparation of processed cheese, the Wisconsin Station concludes that sodium citrate is most generally superior for this purpose.

Sanitary control of milk.—Methods most commonly used in determining the sanitary properties of milk include the standard agar plate count, the direct microscopic count, differential count of coliform organisms, and the methylene blue reduction test.

More representative counts of the total number of bacteria in milk are obtained by the New York (Cornell), New York State, and Vermont Stations by using a modified tryptone-glucose-skim milk agar and incubating samples at 32° C. than by using the standard method.

Suitable media for detecting the coliform group of organisms in milk have been investigated by the Pennsylvania, New York (Cornell), and Maryland Stations. All agree that brilliant green bile broth is one of the most satisfactory mediums developed to date and each has indicated other promising media which will support growth of this group and at the same time inhibit the growth of other organisms.

A slight modification of the methylene blue reduction test, in which the milk tubes were inverted at 30-minute intervals during the reduction period, has been found by the Vermont Station to shorten the reduction time and improve the reliability of the test.

Evidence that methylene blue reduction would designate different classes of milk with respect to total bacterial count was reported by the Michigan Station.

SWINE

Oats for swine.—Based on the results of a great many feeding trials involving a large number of pigs, the Illinois Station concludes that oats may be added to the growing-fattening ration of swine to the extent of nearly one-half of the ration without appreciably affecting the growth rate of pigs. However, the addition of oats in any proportion tended to increase the total amount of feed required per unit of gain made. Grinding oats increased their value for pigs and very materially increased their feed-replacement value. Grinding or hulling oats also markedly improved their palatability. Hulled oat kernels were superior in value to ground oats or to corn, but because of the cost and inefficiency of the process, hulling proved to be a less profitable method of preparation than grinding. A ration of hulled oats supplemented with alfalfa meal, tankage, and salt, when fed in dry lot, induced a condition of stiffness and unthriftiness in pigs which often resulted in death. This was prevented by adding 1.5 percent of bonemeal or a combination of bonemeal and cod-liver oil, but was not prevented by cod-liver oil alone.

Rations for sows.—Corn alone gave good results as a ration during the gestation period for mature sows, at the Indiana Station, when they were so fed and exercised as to maintain a medium condition,

but was unsatisfactory when sows were allowed to become fat. Corn alone was not suitable as a ration for gilts during the gestation period, regardless of condition or amount of exercise. Corn and oats proved to be satisfactory for either sows or gilts when medium condition was maintained. Condition during the gestation period was a more important factor than exercise on the ability of sows to raise pigs. When tankage was added to a corn and oats ration, differences in condition and exercise during gestation did not materially affect the pig-producing efficiency of sows and gilts. Soybeans without minerals were not satisfactory as a supplement, but with minerals proved as efficient as tankage in supplementing corn during this period.

Soybeans for swine.—The Iowa Station found that more than 5 percent of soybeans in the ration over the entire growing and fattening period resulted in undesirable carcasses from the standpoint of the firmness of the fat. The North Carolina Station found that if pigs were fed soybeans during the period when they were storing fat at a low rate and were then changed to rations containing no soybeans, the animals finished in good marketable condition as far as the hardness of fat was concerned. Soybean meal made by the solvent process was unsatisfactory as a protein concentrate for pigs unless toasted, in experiments reported by the Ohio Station. Meal made by the expeller or hydraulic methods was satisfactory.

Pig production.—Results at the Indiana Station showed that 2-year-old sows were more productive than gilts or older sows. The rate of gain of suckling pigs increased with increased birth weight, but as the size of litter increased, the average birth weight per pig decreased.

SHEEP

Rations for ewes suckling lambs.—Good-quality clover hay proved more efficient than early cut timothy hay when each was supplemented with corn in the ewe ration, according to results obtained at the Indiana Station. The lambs made slightly greater average gains, the ewes lost less weight during the suckling period, and produced somewhat more wool on clover hay rations. Oats proved practically equal to corn when fed as a supplement to clover hay. Adding cottonseed meal to the oats and clover hay ration improved its value resulting in greater gains and better finish of the lambs and decreased weight losses of the ewes. The Michigan Station found that the use of cottonseed meal as a supplement to legume hay in the winter ration of ewes was a profitable practice but that barley was generally unsatisfactory as a supplement to hay.

Protein supplements for ewes and lambs.—When the roughage used was half leguminous and half nonleguminous, satisfactory results were not obtained by the Maryland Station unless some source of high protein supplement was supplied in the ration for ewes and lambs. A corn-fish meal ration was readily eaten by lambs, and they made excellent gains on the ration to 5 or 6 weeks of age. Beyond this age, the animals showed a marked dislike for the fish-meal ration, and feed consumption and growth rate fell below that of similar animals receiving cottonseed meal as a supplement. Results of experiments with growing lambs, by the New York (Cornell) Sta-

tion, indicated that soybean meal, linseed meal, and corn-gluten meal had approximately the same efficiency as supplements to a low protein basal ration of corn and timothy hay or corn and corn stover insofar as the utilization of the total protein in the ration was concerned.

Curing lamb.—The flavor of the lean and fat and the aroma of cured lamb legs were improved by the Oklahoma Station by thorough chilling of the meat before the application of cure. Brine cure apparently produced a more palatable product than dry cure, regardless of the length of the chilling period.

See also pages 129, 175.

POULTRY

Potatoes as a feed for chickens.—Raw potatoes were less palatable to laying hens than cooked potatoes in trials by the Michigan Station. Hens maintained their body weight on either ration, but those receiving raw potatoes failed to maintain satisfactory egg production. Excessive amounts of either raw or cooked potatoes had a laxative effect on laying hens. With growing chicks the substitution of dried cooked potatoes or dried raw potatoes for one-half of the yellow corn in a mash ration, or replacing all the corn with dried cooked potatoes resulted in more rapid gains than were obtained in the check lot, but replacing all the corn with dried raw potatoes resulted in greatly retarded growth.

Clean egg production.—Observations by the Missouri Station indicated that most of the soiling of eggs occurs in the nest since more than 99 percent of all eggs were clean before they came in contact with the nest. A higher percentage of clean eggs was produced during the hot dry seasons of the year. The percentage of dirty eggs was reduced approximately 50 percent by gathering eggs four times a day. When open nests were used, darkening the nests materially decreased the percentage of dirty eggs. A higher percentage of clean eggs was gathered from trap nests than from open nests and from birds confined to laying houses than from those on range. Shavings, oat hulls, sawdust, and excelsior were the more effective nesting materials for preventing dirty eggs. Covering the droppings platform with poultry netting and using strips of gravel in front of laying houses did not significantly affect the percentage of clean eggs.

See also page 176.

Egg quality.—A need exists for some definite measure which will give a numerical expression of interior egg quality. The New York (Cornell) Station has shown that the measured vertical height of the firm albumin is highly correlated with its observed grade and proposes this measure as an accurate aid in determining the conditions of the firm albumin. The Washington Station has proposed an albumin index based on the measured height and width of the firm albumin which is also highly correlated with observed grade. A comparison of the albumin index, percentage of firm albumin, and height of yolk of eggs at intervals during the storage period indicated that the albumin index was the only measure showing a constantly high correlation with observed grade at various stages of deterioration. Experiments reported by the Arkansas Station showed that a green-feed supplement consisting of spring oats pasture to unbalanced grain rations made up of equal parts of cracked yellow corn and cracked rice caused a marked

decrease in the storage quality of eggs produced. High levels of cottonseed-meal feeding also resulted in eggs unfit for storage.

Dressing poultry.—Simple and inexpensive equipment for heating wax for use in dressing poultry was devised by the New Hampshire Station. For this purpose an ordinary galvanized 12-quart pail was used as a receptacle for the wax. This was arranged to fit into the round open top of an electric dairy hot-water heater. This method made use of the double-boiler principle, which is valuable in maintaining a steady wax temperature, simplified the temperature-controlling mechanism, and reduced fire hazard.

Crooked breastbone in turkeys.—Evidence that the crooked breastbones commonly found in confined birds may be partially eliminated by either feeding 1 percent of cod-liver oil until the birds are 20 weeks of age or using wider perches or both was obtained by the Pennsylvania Station. A combination of the two practices resulted in fewer crooked breastbones than either one alone. The condition did not exist to any appreciable extent when the birds were on range with ample sunlight and when 4-inch perches were used. The Wyoming Station found that pole roosts about 3 inches in diameter were superior for the control of crooked breastbones to rectangular roosts of either 4- or 1-inch tops.

BEES

Bee food.—The Minnesota Station found that adult bees could live and work and even produce wax for combs when fed only honey or sugar sirup which consisted mainly of carbohydrates, but they could rear young only when provided with a food such as natural pollen which furnishes the proteins, minerals, and vitamins needed by the growing bodies of young bees. Other substances that proved more or less successful included soybean flour and cottonseed meal. Although bees were able to rear young on soybean flour alone, they could not do so on soybean meal alone. A mixture that proved most successful from all viewpoints consisted of 4 parts of soybean meal, 1 part of powdered skim milk, and 20 parts of clear honey. Bees developed their bodies normally when fed meat scrap or commercial casein mixtures. When fed cottonseed meal, ground dried blood, digester tankage, whole oats flour, and whole wheat flour body development proceeded more slowly. Development of the body on corn flour, fish meal, and pea flour was very poor.

Certain varieties of lespedeza were found by the Pennsylvania Station to be of possible value as honey plants. Bees were more numerous on *Lespedeza bicolor* than on *L. sericea*. *L. virginica* in the wild state was readily sought by bees.

Foulbrood-resistant bees.—In cooperation with the Department of Agriculture (B. E. & P. Q.) and other State stations, the Iowa Station has found that resistance to American foulbrood exists in honeybees, and that the factor for resistance can be transmitted to offspring. This finding afforded reason to believe that a strain of bees resistant to foulbrood may eventually become a reality.

Effect of insecticides on bees.—According to the California Station, the beekeeping industry has suffered heavy losses for many years from the application of liquid sprays or poisonous dusts to growing crops from which the bees gather pollen or nectar while ren-

dering an invaluable service in effecting the proper pollination of the blossoms. Indiscriminate airplane dusting, the station believes, may prove especially harmful unless adequately controlled. The New Jersey Station has demonstrated that rotenone dusts are as toxic to honeybees as are the arsenical dusts.

Wintering bees.—Colonies of bees wintered outdoors by the Wyoming Station in tar-paper or sawdust packing produced more honey than colonies wintered in cellars. The granulation of honey in colonies kept in cellars caused heavy losses.

Two-queen bee colonies.—In cooperation with the Department (B. E. & P. Q.), the Wyoming Station has developed an improved method of manipulation for two-queen bee colonies. The queens are placed in the lower hive bodies of each unit and are not disturbed during the normal manipulation of the colonies. Later in the season the two-queen colonies are divided and become single-queen colonies. This procedure has produced more honey per original unit than the straight single-queen or straight double-queen method.

ANIMAL DISEASES AND DISORDERS

Fully realizing the serious losses caused by animal diseases and disorders, the experiment stations are active in efforts to improve the health and well-being of farm animals, and are attacking the problem from all angles. They are determining basic facts concerning the nature and spread of diseases and disorders, the best methods of feeding, care, and management, and, profiting by the experience of plant breeders, are attempting to produce animals resistant to disease and other untoward circumstances. Examples of recent station work having these objects in view are given in the following pages.

HORSES

Abortion in mares.—As a result of many years' study to determine effective means for preventing or controlling abortion in brood mares, the Kentucky Station recommends that all pregnant mares be vaccinated against *Salmonella* abortion each year, 2 or 3 months following the close of the breeding season; that healthy mares be mated to healthy stallions and kept scrupulously clean to prevent streptococcic abortion; that brood mares be kept in small groups to minimize the possibility of the spread of epizootic abortion and other infectious diseases; and that they be kept healthy, reasonably free of parasites of the digestive tract, and fed a ration of hay and grain that contains all the essential elements of nutrition.

Encephalomyelitis.—Experiments at the Utah Station showed that the period of transmissibility of equine encephalomyelitis by two species of native mosquitoes varied between 4 and 10 days and 9 and 19 days, respectively. However, attempts to transmit the disease to horses by means of these mosquitoes were unsuccessful. The Nevada Station has demonstrated that immunization of horses against encephalomyelitis by simultaneous administration of serum and virus is possible.

CATTLE

Anaplasmosis.—Groups of susceptible animals exposed to intermittent feeding of the black horsefly, the horn fly, and *Tabanus*

fuscicostatus Hine that had fed on carrier animals at the Louisiana Station failed to develop anaplasmosis.

Bang's disease (infectious abortion).—Promising results are being obtained in the control of Bang's disease by the use of vaccines. Cows were successfully immunized at the Michigan Station by the use of a vaccine made from a selected nonvirulent strain of *Brucella abortus*, the causative organism of this disease. No evidence was found of any harmful effects of the vaccine on the breeding efficiency or milk production of the animals. The strain of *Br. abortus* used was nonpathogenic for human beings. Success in efforts to control Bang's disease in a badly infected herd was obtained by the California Station through the vaccination of calves and nonpregnant cows with live cultures of *Br. abortus*. Results of agglutination tests at the Montana Station indicated that *Br. abortus* did not become established in range heifers as a result of vaccination. The Kansas Station made a study of the subsequent test behavior of 1,000 cows that tested suspicious at the time of the first test. The results indicated that practically all animals found to be reactors in a dilution of 1 to 50 on the initial test will definitely become either negative or positive within a period of 9 months, and many within a period of 5 months. Such data may be of use in advising herd owners regarding the disposition of certain animals which react in the 1:50 dilution when the herd-test history is available.

Mastitis of dairy cattle.—A study made by the Wisconsin Station of 400 udder quarters showing well-marked evidence of mastitis revealed that the two rear quarters were more often affected with the disease than the two front quarters. There was no significant difference in the occurrence of the disease between the right and left halves of the udder. The feeding of irradiated yeast had no significant effect upon the resistance of the udder to the invasion of mastitis streptococci in tests carried on by the New York State Station. Infected cows fed yeast showed more improvement than infected cows not fed yeast. No prophylactic effect resulted from the addition of irradiated yeast to the diet of mastitis-free cows.

The blood of cattle affected with mastitis was found to be sterile and did not act as a focal factor in studies reported by the Virginia Station. The blood was evidently highly bacteriolytic and rapidly destroyed the disease organism.

Functional sterility in cows.—Based upon a limited number of cases, the Michigan Station concluded that douches of physiological saline solution, together with ovarian massage, were of value in treating some cases of so-called functional sterility.

SHEEP

Internal parasites of sheep.—A mixture of copper sulphate and salt, 1:30, when fed to sheep ad libitum and consumed at the rate of 0.5 pound per sheep per month, did not adequately control the development of nematode parasites in the gastrointestinal tract of sheep and resulted in copper sulphate poisoning in some cases, in tests reported by the West Virginia Station. When used as drenches the 1.5-percent solution of copper sulphate and the mixture of 1.5-percent solutions of copper and nicotine sulphates were equally efficient in the control of both nematode and cestode infestations.

Pregnancy disease of sheep.—Inadequate feed was found to play an important part in causing pregnancy disease (ketosis) of sheep, according to results of studies by the North Dakota Station. This disease sometimes causes heavy losses among ewes. The station suggests that the nutrition of ewes should be such that their condition improves with advancing pregnancy and recommends that molasses be used to supplement roughages of low quality.

SWINE

Toxicity of diseased grain as swine feed.—The Minnesota Station found that a water extract of scabby barley administered orally was sufficient to make a pig weighing 100 pounds vomit. In feeding tests with pigs it was demonstrated that *Fusarium graminearum* produced a toxic principle in wheat, barley, and corn. The toxic principle may persist in whole barley for at least 3 years. The amount of the toxic principle present in scabby barley usually was proportional to the degree of shriveling. Barley blighted with *Helminthosporium* and *Alternaria* was not toxic to pigs, although it contained as much as 31 percent by weight of blighted kernels. Barley naturally infected with 16 percent of scab was extremely toxic to pigs, and pigs refused to eat barley with 32-percent scab infection by weight. *Fusarium* poisoning caused pigs to lose their appetite, became listless, weak, often vomit, and sometimes die. Some of the toxic principle was removed by soaking and washing the infected grain.

POULTRY

Fowl paralysis.—Fowl paralysis was readily transmitted by pen contact from affected to nonaffected chicks, in experiments by the Idaho Station. The disease developed to a less extent in chicks from an affected flock than in chicks from a nonaffected flock when brooded together. The disease was more prevalent in chicks from pullet-breeding stock than in those from hen-breeding stock from the same affected flock. Evidence of variation in inherited resistance was apparent in different families. No major variation was found in the incidence of the disease in range-raised and confined birds.

Internal parasites.—Recent investigations by the Hawaii Station have shown 10 species of the flour beetle, the sand hopper, 3 species of grasshoppers, and the rice weevil, collected from poultry farms, to be naturally infested with infective larvae of the gizzard worm. Frequent removal of chicken manure from poultry yards and preventing fowls from eating beetles, grasshoppers, and sand hoppers was suggested as a means of control for the worm.

Data obtained in studies by the Wisconsin Station indicated that chickens of all ages up to and including 15 months were susceptible to infection with the parasite *Eimeria tenella* and showed symptoms of acute coccidiosis following infections. When chickens 3 months old or older were infected they were considerably more resistant to infection than were chickens infected when not over 2 months old.

An encephalomalacialike paralysis of chicks.—The Connecticut (Storrs) and the Rhode Island Stations noted the occurrence of a brain disorder in young chicks. Large fast-growing chicks from 2 to 7 weeks of age were most susceptible. Laboratory tests indicated

that it was not of an infectious nature, while feeding tests indicated that some factor or factors in corn were responsible for or contributed to the disorder. The Wisconsin Station described a chick paralysis due to vitamin B_4 deficiency and differentiated between this type of paralysis and the encephalomalacialike paralysis.

Blackhead in turkeys.—Results obtained in studies by the Maryland Station have shown that blackhead is not regularly, if ever, transmitted through the egg. By incubator hatching and rearing poults in isolation from adult turkeys or chickens or soil contaminated by such birds the disease has been consistently controlled. The most frequent time of death in poults reared in the breeder yard was during the second month of their life. Blackhead also appeared in grown turkeys, most commonly causing the death of young hens in heavy egg production. The presence of blackhead parasites in contaminated soil was demonstrated, and experiments indicated that flies may be regarded with suspicion as carriers of the disease.

A blood disease of turkeys.—A new protozoan disease studied by the Virginia Station caused affected birds to lose their appetite, appear droopy, and to have a tendency to lie down. Such birds when disturbed move with difficulty, and when excited in the later stages may fall, gasp, go into a coma, and finally die. Visible symptoms usually lasted for only 2 or 3 days, at which stage the birds either died or recovered. The birds were usually somewhat emaciated and appeared anemic. The flesh was flabby and the muscles assumed a brownish color. Occasionally small hemorrhages and ulcers appeared in the intestines. Microscopic examination of the blood usually showed the protozoa in large numbers. The causative organism was transmitted by a blackfly from infected to normal fowl.

Pullorum disease in ducklings.—An outbreak of pullorum disease in 4-week-old chicks and 1-week-old mallard ducklings, together with circumstantial evidence to show that the disease was transmitted to the ducklings from the chicks was reported by the California Station.

GENERAL

Selective habitat of timber milkvetch.—The Wyoming Station finds that timber milkvetch (*Astragalus hylophilus* (*A. campestris*)) is restricted in growth to soils derived from certain geological formations and may be taken as an indicator of these formations. The pathology of animals affected by this plant point definitely to a toxic mineral such as tin, molybdenum, or arsenic found in organic combination in the plant extracts. Within the geological formations this plant is quite generally confined to aspen growths, aspen-pine associations, and pines.

Locoweed.—The isolation of the toxic principle of the locoweed (*Astragalus earlei*) in comparatively pure form is reported by the Texas Station. The name "locoine" was given to the principle. Tests for selenium in locoine were negative.

See also page 21.

Spray poisoning of sheep.—The Washington Station reported a case in which approximately 85 percent of a band of 1,000 sheep died after grazing an apple orchard which had been sprayed nine times between May 10 and August 13 with lead arsenate. Approximately

58 pounds of lead arsenate per acre had been applied to the area. Between the previous spring and the date when the sheep were allowed to graze 0.53 inch of rain had fallen. An analysis of the forage under the trees showed that it contained 0.58 percent of arsenic and 1.44 percent of lead.

Pullorum disease in captive quail.—Culture made from the organs of dead quail chicks at the Florida Station yielded a micro-organism having the characteristics of *Salmonella pullorum*. The infection appeared to have been introduced by birds raised in captivity and to have been spread to a considerable extent by means of the incubator. The station points out that while pullorum disease is not of particular importance in wild quail at present, the release of pullorum-infected birds from quail farms is a potential menace to the future of this game bird. This is particularly true at this time when the restocking of the wild supply is a part of the conservation program of many States.

Horseflies.—The Arkansas Station reports the occurrence of 47 species of horseflies in that State. Two of these, the little "greenheads" (*Tabanus costalis* and *T. lineola*) cause the most injury and annoyance to livestock. Since the flies in most cases breed in mud, bordering ponds, and sluggish watercourses, it was suggested that the elimination of such areas would serve as a control measure for the flies.

Treatment of dysentery in young animals.—The Oregon Station reports the successful treatment of lambs, calves, colts, and pups for dysentery through the use of milk soured by *Lactobacillus acidophilus*. It is pointed out that the milk to be effective must be properly made and cared for.

Grazing cattle and sheep together.—Grazing tests by the Louisiana Station on permanent pastures established on rich alluvial soil showed the value of improving such pastures by the increased gains of cattle on them. Beneficial results were realized where sheep and cattle were grazed together, but economical gains were not obtained from such pastures when sheep were grazed alone. The plan of grazing cattle and sheep together was a more effective means of controlling intestinal parasites in lambs than biweekly drenching either with a 1-percent solution of bluestone or a solution containing 1 percent each of bluestone and nicotine sulphate. Calves grazing in combination with sheep had fewer intestinal parasites than calves grazed in the regular cattle pasture. On pastures grazed with cattle, there was a predominance of Bermuda grass, on those grazed with both sheep and cattle a comparatively high percentage of Dallis grass, while those grazed by sheep alone had a higher percentage of broomsedge.

H. W. Marston,
G. Haines,
E. C. Elting, and
W. A. Hooker.

FOODS, HUMAN NUTRITION, AND OTHER HOME PROBLEMS

As has been emphasized in early reports of this series, the problems of the home are largely those of consumption and are concerned mainly with questions of quality. The producer is also concerned with

quality of his products but is learning that quality which pays is no longer that of outward appearance alone but also that which makes the greatest contribution to the health and welfare of the human being. Through research the housewife too is being taught the same lesson and being aided to develop sound and reliable standards of quality in consumer's goods and services. Some of the contributions of the experiment stations during the past year of direct benefit to the home along these lines are noted below.

QUALITY IN FOODS

The housewife thinks of quality in foods in terms of the foods themselves—meats, poultry, eggs, and milk; bread, cake, and pastry; and fruits and vegetables—rather than in terms of the specific factors affecting quality. For this reason selected examples of the work of the year in the field of quality in foods will be reviewed under specific foods.

Meats.—The best conditions for the care of meat in the household refrigerator have been very thoroughly studied by the Iowa Station using ice and electric refrigerators, all kinds of meats commonly stored in this way for family use, various containers and wrappings, and different times and temperatures of storage. All samples were tested for shrinkage, appearance, and signs of spoilage after storage, and some were cooked and judged for flavor. Cooked roasts were returned to the refrigerator for further storage. The greatest losses in weight occurred with uncovered samples and the least with those wrapped in paraffin or parchment paper or kept in a covered container. Cooked roasts cooled before being returned to the refrigerator showed greater shrinkage than those returned without being cooled. As far as appearance and general palatability were concerned the products wrapped or kept in closed containers were for the most part preferable to those stored uncovered, but spoilage took place rather more quickly. It was concluded that cooked roasts may be stored satisfactorily for 2 or 3 days at temperatures of 48° F. or below when wrapped or covered, but that for longer periods the meat should be left unwrapped or wrapped very loosely in paraffin paper and kept at temperatures below 45°. Unwrapped hams stored at such temperatures were satisfactory after a 2-week period, and sausages in cases wrapped loosely in parchment paper, for from 7 to 8 days. Seasoned ground sausage meat similarly wrapped was most desirable if kept not longer than 48 hours and ready-to-serve meats, from 24 to 48 hours. Steaks frozen and stored in the freezing unit of the electric refrigerator were more palatable if covered or wrapped during storage and cooked without defrosting.

Freezer storage of farm-produced meats for family use has raised many problems of the handling and cooking of the frozen product. At the Minnesota Station a study has been made of the effect of different thawing temperatures (175°, 24–25°, and 2°–4° C.) on the time of cooking and quality of various cuts of pork and beef which had been wrapped in moisture-proof paper and left in a freezing cabinet at −18° C. (0° F.) until frozen solid. For thawing at the higher temperature the meats were unwrapped, the roasts placed in an electric oven preheated to 175°, and removed when the thermome-

ter registered 5°, the steaks thawed under the broiler flame with the oven regulator set at 175°, the chops seared on each side in a frying pan, and the pot roasts seared and simmered in water until a skewer could be forced through. For the lower temperature the meat was left until thawed in the laboratory or in a conditioning room (24°–25°) and in a mechanical refrigerator (2°–4°). Roasting was done at constant temperature, 175°, according to the standard method of the cooking committee of the cooperative meat investigations. The roasts which had been frozen cooked more quickly than the unfrozen, and those thawed at the higher temperature more quickly than those thawed at the lower temperature. The total losses were somewhat higher for the roasts thawed at the high temperature than for those thawed at the lower temperature or for the unfrozen meat. The press fluid (or juiciness) of the frozen pork thawed at 24°–25° was higher than the unfrozen pork. Flavor, tenderness, and juiciness as measured by palatability tests were not affected by freezing or thawing at either of the temperatures.

A short-time study along similar lines was made at the Illinois Station, with freezing for 48 hours at temperatures of −10°, 6°, and 10° F. and thawing temperatures of 39° (electric refrigerator), 54° (ice refrigerator), about 81° (room temperature), and for comparison nonfrozen and frozen but not thawed similar cuts. For the roasts a preliminary searing at high temperature was followed instead of the constant-temperature method used in the Minnesota study. The palatability of the frozen and nonfrozen meats ranked about the same except that the frozen pork scored higher than fresh for tenderness and juiciness. The samples which had been thawed before cooking were given a slight preference over those which had been cooked without thawing. Losses in weight during thawing and during cooking did not vary significantly for the different methods tested. Considerable differences were noted in the time required to cook thawed and unthawed meats, the unthawed always requiring more time than the thawed. The maximum time which frozen meats could be safely kept after removal from frozen storage was 2 to 3 days in an ice refrigerator and 3 to 4 days in an electric refrigerator, depending on the thickness of the pieces.

In the 1936 report on the stations attention was called to the use of the meat thermometer to replace guess work in the roasting of meats, and preliminary studies at the Texas Station were noted in which it was shown that the less tender a cut the better chance it has for becoming tender on roasting if a low oven temperature, 125° C. (257° F.), is used instead of a high temperature, 225° C. (437° F.), provided the roasting is continued to a definite internal temperature as registered on the meat thermometer. The secret of this, according to further reports from the Texas Station, appears to be the longer time required by the less tender cuts to reach the same internal temperature. With chuck roasts of beef, for instance, the temperature goes up fairly rapidly for a while and then there is a long lag when there is almost no change in the thermometer reading. With a tender rib roast of beef the rise in temperature is more uniform and with lamb there is practically no lag. If a low oven temperature is used the cooking time is longer for all roasts than with a high temperature, but the difference is much more marked with the less tender than

with the tender cuts, 370 minutes for chuck, 194 minutes for beef rib, and 105 minutes for leg of lamb. According to the Texas investigation more work needs to be done before anyone is able to recommend processes of cooking which will uniformly produce tender roasts. Present knowledge would indicate, however, that a housewife will have a better chance of obtaining a tender roast if she cooks it at a low than if she cooks it at a high oven temperature.

Which is preferable, a standing or a rolled beef rib roast? The Minnesota Station has attempted to answer this question by preparing standing and rolled two-rib roasts from the right and left cuts of the same animal, roasting them at constant oven temperature 149° C. (300° F.) to the same internal temperature 58° C. (137° F.) and judging them according to the score card of the cooking committee of the cooperative meat investigations as well as taking the usual records of evaporation, dripping, and total cooking losses. The standing roasts had a larger quantity of juice with correspondingly lower total losses, and required less total cooking time and minutes per pound than the rolled roasts. The scoring showed that there was a slight tendency for the standing roasts to have a richer quality of juice than the rolled, but there was no consistent difference in flavor.

The effect of cooking upon the composition and serving value of four cuts of beef—prime rib, chuck, top round, and heel of round—was studied by the Missouri Station with calculations of the total cost of servings of each. The meats were all roasted at constant temperature of 150° C. to the underdone, medium-done, and well-done stages. With a few exceptions increase in doneness caused an increase in the moisture, fat, and total ash of the drippings, and a very slight increase in the protein. The cooked cuts were all richer in protein, fat, and total ash than the corresponding uncooked cuts, but not to an equal extent in all of the cuts. Considering the original cost of the meat, the cost of the gas consumed, and the number of servings obtainable per pound of uncooked meat, the heel of round cost 6.2 cents, the chuck 6.7, the prime rib 8.9, and the top round 10.6 cents per serving. These figures are of interest, of course, as relative rather than absolute costs.

Top shoulder clod, rib, and top and bottom round of beef were selected by the Kansas Station for a study of the composition of certain cuts as affected by grade, location in cut, and method of cooking. The cuts were boned, and all but the clods rolled before cooking, which was done by roasting at a constant temperature of 150° C. to internal temperatures of 71°–78°. The bottom round and one of the clods were braised, or cooked in a small amount of added water in a covered roaster on top of the stove.

As in the Missouri study, considerable variation in composition was found not only among the various cuts but also in different grades of the same cut and in different locations of cuts of the same grade. All the cuts showed increase in protein and fat and a decrease in moisture after roasting but the percentage increase in protein was higher and in fat lower in the rib than in the leaner cuts. As a result, the amount of protein in the rib cut after cooking became comparable with that of the lean cooked top round ordinarily regarded as a more abundant source of protein.

The influence of the condition of the ewe on the cooking quality of mutton has been studied by the Missouri Station for the purpose of giving reliable recommendations for the choice of the animal for slaughter, of cuts from a given animal, and of methods of cooking. Cuts from fat ewes proved more satisfactory than from thin ones, for they gave less evaporation loss, required less gas and less time per unit weight to cook, were superior in tenderness, juiciness, and desirability of flavor of lean, and gave a higher percentage of edible meat from legs, shoulders, and chops, and a lower percentage of meat suitable only for ground loaf. As for selection of cuts, legs and shoulders rather than chops are recommended when cooking losses, fuel consumption, serving value, and all factors of palatability except tenderness are considered. Large pieces are preferable to smaller ones from standpoint of cooking losses, time, and fuel required per unit of weight. If cuts from thin animals only are available, ground meat is most economical on account of the higher percentage yield of edible meat. Drippings from ground meat especially should be used in gravy to improve the flavor and juiciness of the loaf. Oven temperatures recommended are 150° C. for legs and ground loaves, 175° for shoulders, and 175° after a searing period for chops.

See also page 121.

Potatoes.—As noted in the 1936 report, much attention is being given at several of the experiment stations to factors affecting the cooking quality of potatoes. Many of these factors, such as the conditions under which potatoes are grown, are beyond the control of the housewife, but she can play some part in furnishing her family with potatoes of desirable quality, in the matter of selection, storage, and cooking methods.

In a study at the Vermont Station of quality demands in household buying of various foods the investigator came to the conclusion that housewives are apt to buy potatoes without either looking them over or asking for specific qualities. In a much more extensive study conducted by the New York (Cornell) Station in two large cities the housewives who were observed in the stores likewise did not seem to be discriminating in their buying, since a large percentage asked for potatoes with no specification of the qualities desired. When these purchasers were interviewed in their homes and asked what qualities they desired in potatoes more than half mentioned mealiness. When asked what qualities were avoided as much as possible those mentioned most frequently were the poor qualities usually considered in the proper grading of potatoes, too large or too deep eyes, too large or too small potatoes, and external defects. A demand for grading in potatoes would simplify the housewife's task in potato selection.

Since mealiness is the physical quality most desired in potatoes, several of the stations are continuing their attempts to find a satisfactory method for judging mealiness. Among these is the New York (Cornell) Station, which is making a definite effort to replace subjective tests by objective ones, using several pieces of apparatus developed for the purpose. One of these, known as a slot-extrusion tester, distinguishes between mealiness and sogginess by the load required to force the cooked potato through a 50-micron slot. A relation

between the mealiness of a cooked potato with its specific gravity in the raw state has been noted by the Ohio Station. The ease with which a loaded needle (penetrometer) penetrates into a cooked potato has frequently been used to determine doneness in potatoes, but, as recently shown by studies at the Colorado Station, this test does not necessarily indicate mealiness in spite of the fact that there is a relationship between starch content and mealiness and between starch content and penetration. Although these studies seem very technical and far removed from practical advice to the housewife in the selection of potatoes for the table, they are mentioned as showing the efforts which are being made to find some measure of cooking quality in potatoes which can be applied in their grading, thus doing away with the rather unsatisfactory method of buying by sampling and cooking to determine quality.

In the Colorado studies referred to above, it was observed that in boiled potatoes those of high starch content which have been cooked until they taste done, as determined by a mellow rather than crisp feel to the tongue as well as a distinct difference in flavor, will be much more solid than those of low starch content. As the cooking is continued beyond the "done" stage the potatoes become progressively softer. It is, therefore, fortunate that the starch content of a potato is highest in the outer portion, since in cooking this portion is maintained at a high temperature for a longer period of time than the center portion. If the distribution of starch were reversed the potato might differ considerably in hardness in the various portions, even though it tasted done. Possibly the poor cooking quality of potatoes which tend to slough before they are done in the center may be due to poor distribution of the starch.

If potatoes are raised on the farm for home use or bought in quantities, storage conditions during the winter become a factor affecting quality. To determine the importance of this factor the Montana Station selected two outstanding commercial varieties raised in the State, the Bliss Triumph and the Russet Burbank, or Netted Gem, and two contrasting types of storage cellars—one a regular potato storage house in which temperature, humidity, light, and ventilation were under proper control, and the other a vegetable room in a private house, with no control of temperature and humidity and a single north window for ventilation and light. The storage house was described as "cool and damp," with temperature ranging from 37° to 46° F., and the home vegetable room as "warm and dry," with temperature ranging from 55° to 60°. The potatoes were placed in storage October 1 and at the end of 6 months were subjected to various tests including cooking tests for palatability and biological tests for vitamins B and C, with a few chemical tests for C.

Both varieties kept in the cool damp cellar remained firm throughout the entire storage period and showed only slight evidence of sprouting by the first of May. Those kept in the warm dry cellar gradually withered, and the Bliss Triumph began to sprout in January and the Netted Gem in April. The flavor of the Bliss Triumph was better in the samples stored in the cool damp cellar and of the Netted Gem in the warm dry cellar. The Netted Gem also developed a greenish-yellow color in the cool cellar. This was not associated with a high solanine content, for both varieties kept in both storage

places increased in solanine content as storage progressed. A difference in varieties of potatoes with reference to the effect of storage was also shown by the Ohio Station, which found that Russet Rurals seem to deteriorate less in cooking quality during storage than the Green Mountain variety.

Because of the importance of potatoes as an inexpensive source of vitamin C, the Montana Station has determined by the rapid chemical method the vitamin C content of potatoes cooked in a variety of ways. With one exception the Bliss Triumph potatoes always contained more vitamin C in a given weight than the Netted Gem. When cooked by ordinary methods, baked potatoes ranked highest in vitamin C, followed by steamed, boiled, and pressure-cooked. After storage there appeared to be somewhat less loss of vitamin C in the potatoes kept in warm dry than in cool damp storage. In general, servings of cooked potatoes in the spring after storage in the cool damp cellar contained about two-thirds as much vitamin C as in the fall.

It is well known that potatoes which have been stored at too low a temperature accumulate sugar from a break-down in starch and that such potatoes are particularly undesirable for frying chips, as shown by earlier work of the Maine Station and also of the Department of Agriculture (B. H. E.). It is possible to recondition such potatoes to some extent by holding them for a time at a higher temperature, but this is not always feasible. Approaching the problem in a different way the Minnesota Station found that chips of good quality can be prepared from potatoes which have developed a high sugar content in storage by changing the temperature and time of frying. As the sugar content of the potato increases, the frying temperature (or temperature at which the crisping and browning occurs after the water has evaporated) must be decreased and the frying time correspondingly increased. In the laboratory work the sugar content was determined by testing with picric acid. Potato slices giving a red color with this reagent made desirable chips when immersed in fat at a temperature as low as 325° F. (163° C.) and fried at 270° F. (132° C.). The Burbank variety, which with picric acid never tested above a deep orange, made good chips at an immersion temperature of 365° F. and a frying temperature of 290°.

Soybeans.—Quality studies on soybeans as human food, particularly in the so-called green-vegetable state, are continuing at several of the experiment stations in cooperation with the Department of Agriculture (B. P. I.). At the Illinois Station alone more than 450 varieties and selections have been cooked by standard methods and scored for palatability and other factors. From these 17 superior ones have been chosen. These are described as attractive green vegetables when immature and large light-colored beans when dry, quite different from the field soybeans now being grown. There is considerable prejudice to be overcome in the acceptance of soybeans as a human food, but properly selected varieties not too strong in flavor offer great promise in both the green-vegetable and dried state. The Indiana Station reports a very favorable response from farm families using soybeans cooked in different ways and states that either green or dry edible soybeans may be canned although they need longer processing in the pressure cooker than snap beans. The

Alabama Station has found that the yellow- and green-seeded light-colored soybeans have a much more attractive appearance when canned than the dark-colored varieties of soybeans or the usual varieties of cowpeas used so extensively in the South.

Food value as well as palatability has also been given attention in soybean studies. Aside from moisture content which, of course, decreases as the beans mature, there is little difference in the proportion of the various food constituents from the time the green beans are ready for table use until they reach the dry-bean stage, according to tables of composition prepared by the Illinois Station. Wide variations in content of carotene, the vegetable source of vitamin A, were found by the Alabama Station in different varieties of soybeans and these variations could not be predicted from the depth of yellow color in the dry beans. Compared with other beans, however, they are as a class a good source of vitamin A. All in all, soybeans are a good vegetable crop to consider for the farm garden. One point in their favor, according to the Illinois Station, is that they are ready for use as a green vegetable in September when vegetables are none too plentiful. Another argument in their favor, suggested by the Indiana Station, is that the crop is highly resistant to the Mexican bean beetle and withstands drought well.

Lima beans.—In work at both the Massachusetts and New York State Stations fresh green lima beans were found to be an exceptionally good source of vitamin C, comparing favorably with orange juice and richer than green peas and tomatoes. With the many factors which, as pointed out in the 1936 report, tend to destroy vitamin C during the interval between harvesting and eating the product, it is of interest to trace these losses in such a good source of vitamin C as lima beans and see to what extent they may be avoided. According to the New York State Station the original vitamin C content varies rather widely with variety and size. When graded according to size the large-seeded pole varieties were found to be richer in vitamin C than the large-seeded bush varieties. When beans of a single variety were graded according to size, the smaller beans in the lot contained a higher percentage of vitamin C than the larger ones. When stored in the pod after picking, the beans retained their original vitamin C content very well, but when shelled the loss was much more rapid. Even when kept in moistureproof packages, the shelled beans lost about twice as much of the vitamin as beans in the pod. This loss is one that can easily be avoided by the housewife through demanding unshelled rather than shelled beans in the market, or picking and shelling them just before cooking if the supply comes from the home garden. Another point to remember is that the loss of vitamin C is much less at refrigerator than at room temperature.

In preparing shelled lima beans for frozen storage the New York State Station found that approximately one-third of the vitamin C was lost during the blanching in boiling water according to the recommended commercial blanching time of 150 seconds. A much shorter time (45 seconds for the small sizes and 60–75 for the larger sizes) was found adequate to prevent the development of off-flavors and loss of color in the frozen product during storage and is worth considering in the preparation of lima beans for refrigerator-locker

storage. Frozen beans showed no loss in vitamin C if sufficiently low temperatures were used for freezing and storing. In the New York State Station study the blanched beans, after being quickly cooled in running water, were drained and packed dry in moistureproof cartons, quick-frozen in a Birdseye Multiple Froster, and stored at −17.8° C. (0° F.). In recommendations from the Oregon Station for refrigerator-locker storage freezing temperatures of −5° to +5° F. with storage temperature the same or not to exceed +15° are given.

Sweet corn.—This vegetable is used so extensively in the canned, and more recently also in frozen state, that factors affecting its quality are particularly important. Several of the experiment stations are studying varieties and strains especially adapted for canning from the standpoint of yield and vitamin A content (yellow varieties), while others are particularly concerned with the food value, especially vitamin C, as affected by methods of preservation. The housewife is interested in quality standards for commercially canned and frozen corn and in the best methods of preserving sweet corn for winter use in the home.

The well-known association of vitamin A with yellow pigment has been one of the factors responsible for the popularity of Golden Bantam corn in regions where it can be grown successfully. With the development of many hybrids of this popular sweet corn the question arises as to their vitamin A value. Although this point does not seem to have received particular attention in experiment station research, studies at the Illinois Station of various hybrids of yellow field corn have shown that depth of yellow color is not always a clue to the vitamin A content of the cured corn, some varieties of a pale yellow color having more carotene, the plant source of vitamin A, than others of a deeper color. However, in more recent work at the same station the darker kernels of the same ear were found richer in carotene than the lighter.

Golden Bantam was the variety used chiefly by the Massachusetts Station in an investigation of the stability of vitamin C in sweet corn in shipping, freezing, and canning. Values of 40 to 60 international units per ounce were obtained with raw, fresh cooked (cut or cob), frozen, and whole-grain corn of this variety. Among other findings of interest to the housewife are the following: Sweet corn picked early in the season had a somewhat higher vitamin C content than that picked late in the season. Market corn compared favorably with freshly picked corn. After 24 hours' storage in the husk at room temperature the loss in vitamin C was less than 10 percent and after 4 days, less than 50 percent. Exposure of canned sweet corn, after opening the can, had little effect on the vitamin C even after 3 days' storage in the refrigerator at 40° F. Complete defrosting of frozen corn at the same temperature required 24 hours and resulted in only about 3 percent loss of vitamin C, while complete defrosting at room temperature resulted in only a 6-percent loss. The loss in vitamin C in heating sweet corn—fresh raw, frozen, or canned—until ready for the table was slight, amounting to less than 9 percent. Cream-style canned corn contained a little less vitamin C than whole kernel and this in turn than vacuum-packed. In general, canned sweet corn sold in the market was found to be a fairly good source

of vitamin C, with some brands equal in value to fresh sweet corn. All in all the vitamin C in sweet corn seems to be much more stable than in lima beans.

Golden Bantam corn was also selected by the Montana Station for a study of the effect of different methods of home preservation—canning, drying, salting, and fermenting—on keeping quality, palatability, and vitamin content. The records of spoilage in the canned corn processed by different methods and for various times furnish convincing evidence of the folly, to say nothing of the danger, of attempting to can nonacid vegetables by any other method than the pressure cooker. With necessary modifications in pressure for the high altitude, about 5,000 feet, there was no spoilage in the corn processed in the pressure cooker for 90 minutes at 240° F. and for 70, 75, and 80 minutes at 250°. Processing for 70 minutes at 250° is recommended to the housewives of the State as a safe method to follow. Spoilage in corn canned by water-bath, steam, and oven methods varied from 36 to 100 percent.

Of the other methods tested, salting gave the most satisfactory product, ranking higher in palatability scores than canned corn. The method followed consisted in packing in a stone jar alternate layers of salt and cut corn in the proportion of 1 to 4 or 7 parts, covering it with a weighted cover, and letting it stand for 2 or 3 weeks and then removing to clean glass jars and sealing. The corn for this method and for drying was precooked on the cob for 8 or 10 minutes before cutting. The dried corn was prepared by spreading similarly treated corn in thin layers and drying in a well-ventilated oven at from 100° to 150° F. Fermented corn was prepared by covering corn cut from the cob without preheating with a weak vinegar-salt brine and letting it stand for 2 or 3 weeks in a warm place and then transferring to clean glass jars and sealing. The dried, salted, and fermented corn kept very well if handled as suggested. With dried corn the greatest chance for spoilage came from souring during the drying process and was controlled by drying as rapidly as possible without overheating. With the salted and fermented corn the tendency to mold was reduced by transferring the material at the proper time to glass jars and sealing.

Rather unexpected results were obtained in the vitamin A tests, for the cooked fermented corn was twice as effective, the canned corn half as effective, and the dried and salted corn just as effective as the raw frozen corn. All forms of the preserved corn were less effective as a source of vitamin B_1 than the raw corn, the loss being particularly marked in the fermented corn. The same stability of vitamin C in corn prepared in different ways was noted as in the Massachusetts Station when the vitamin content was determined chemically, but in a few guinea pig feeding tests the canned corn was only half as effective as the raw frozen corn.

Cabbage.—Many housewives will welcome the news that the New York (Cornell) Station has succeeded in developing a cabbage that has practically no odor, for if it were not for the somewhat unpleasant odor which permeates the house when cabbage is being cooked even by the most approved methods, this inexpensive vegetable would probably have wider use. The new odorless cabbage, which has been named Cornell Early Savoy, is described as "uniformly well crinkled,

dark green foliage; heads of medium size, light green in color, semi-pointed, very crisp and succulent. Exceptionally fine for cooking."

Cabbage has always been highly regarded as a source of vitamin C with the distinction that raw cabbage is preferable to cooked because of its higher content of vitamin C. With the development of quick chemical tests for this vitamin it has been possible to make finer distinctions concerning the quality of cabbage with respect to vitamin C under different conditions. The New York State Station reported:

> The varieties of cabbage commonly grown for harvesting early in the summer are much higher in vitamin C than those usually cut late in the autumn for kraut manufacture and winter storage. Whole heads of raw cabbage slowly lose vitamin C during storage. The rate of loss of ascorbic acid [vitamin C] is much higher at ordinary room temperatures than when the cabbage is stored under refrigeration. During the cooking of cut cabbage a considerable proportion of its ascorbic acid is dissolved in the cooking water. Approximately one-fourth of its vitamin C content is lost in the first few minutes of cooking. After that the loss is slight. Even though cooked cabbage is placed in a very cold refrigerator, it slowly loses its ascorbic acid, and at the end of two days' storage approximately only one-half of its vitamin C content remains.

Tomatoes and oranges.—From a nutritional point of view the chief interest in tomatoes is in their vitamin C content, for they are one of the most readily available and inexpensive sources of this vitamin. It was first thought that oranges and tomatoes had about the same vitamin C values. Later it appeared that tomatoes were only about half as rich as oranges in this vitamin. More recent work, as noted in the 1936 report on the stations, has shown that certain varieties of tomatoes are very much richer in vitamin C than others. This has been confirmed in an extensive series of tests at the Massachusetts Station of varieties and strains grown under identical soil treatment and care on the station experimental plats. In the 98 varieties or strains tested the values ranged from a low of 0.13 milligram to a high of 0.44 milligram per gram. This shows that one variety may be from two to three times as rich as another in vitamin C.

Freshly extracted orange juice (eight varieties) has been reported by the Department of Agriculture (B. H. E.) to have a vitamin C content ranging from 0.32 to 0.62, and by the Montana Station (two varieties), from 0.39 to 0.62 milligram per cubic centimeter. In comparison with this range of 0.32–0.62 milligram per cubic centimeter 20 of the tomato varieties tested by the Massachusetts Station had values of 0.32 milligram per gram or above. In other words, tomatoes may be as rich in vitamin C as certain varieties of oranges. Different strains of the same variety of tomato in some cases showed as wide variation as was found between different varieties. Consequently, advice cannot be given as yet as to the selection of tomato varieties for the home garden for the best yield of vitamin C, although the averages for the different strains give some indication. Various strains of a new variety being developed at the station gave an average vitamin C content of 0.37 milligram per gram as compared with 0.32 for the Comet, 0.31 for the John Bair, 0.29 for the Bonny Best, 0.27 for the Marglobe, 0.25 for the Rutgers, and 0.21 milligram per gram for the Pritchard. The station is of the opinion that "with a little care, the canners of tomatoes and tomato juice should be able to select and perfect improved strains of tomatoes of higher vitamin C potency

than are now grown commercially." This was suggested in the 1936 report as possibly accounting for the wide differences now existing in the vitamin C potency of different commercial brands of tomato juice.

Other points brought out in this Massachusetts study were that there is no relation between the size of a tomato and its vitamin C content; that degree of ripeness has no significant effect on the vitamin C content; and that so long as the fruits remain firm and sound the vitamin C content will not be seriously affected during shipment, in markets, or in canneries.

As noted above, oranges as well as tomatoes have been found to vary considerably in their content of vitamin C. The Florida Station has traced the concentration of vitamin C and acid in ripening oranges through and beyond maturity and has found that both vary with the physiological age of the orange. In a later ripening variety (Valencia), both vitamin C and acidity decrease with maturity, while with early (Parson Brown) and midseason (Pineapple) there is an increase in vitamin C up to maturity, followed by a decrease. The station also found that a high concentration of vitamin C within a variety is associated with a high-quality juice, but that a juice ranked as of poor quality does not necessarily have a low concentration. Storage tests at ice-box temperature (40° F.) have shown that an increase in concentration of vitamin C up to 30 percent may occur (although not always) in the first few weeks of storage.

Miscellaneous.—Meat, potatoes, soybeans, lima beans, sweet corn, cabbage, tomatoes, and oranges have been singled out for special attention to illustrate, with a few of the more common foods on which considerable work has recently been done, the type of research at the experiment stations which is gradually improving the quality of agricultural food products and establishing standards by which quality may be judged. Attention should be called to one or two general publications of the year which are of unusual value in summarizing work along this line of interest and value to the housewife who is concerned with quality in foods. One of these, a contribution from the Massachusetts Station (B. 338) discusses each vitamin in turn with the effect of such factors as maturity, storage, freezing, heat, and drying on its stability in different fruits and vegetables. Although the bulletin is not confined to experiment station research, at least 21 of the experiment stations are included as sources of the information given. To the housewife the summary is of particular value in telling in general terms what steps to take to conserve the original vitamin values of the food she selects and prepares for the family table.

A publication of special interest to the rural housewife in localities where refrigerator-locker storage is available for home-produced foods is a circular (No. 122) from the Oregon Station. According to this publication refrigerator lockers are increasing by the thousands annually, and housewives are eager to utilize such storage facilities to preserve foodstuffs. They are cautioned, however, that—

> fresh fruit or vegetables used for freezing should be of the highest quality; and as maturity affects the flavor, the stage of maturity should be watched. Green or overripe fruit should not be used because the products will be flavorless when "defrosted." Overmaturity in vegetables will mean a very tough

and stringy product, the flavor and appearance also changing with age. The best stage of maturity for eating or other use in the fresh stage is also the best condition for freezing.

This advice is followed by information on proper temperatures and general methods of preparation and specific methods for a number of fruits and vegetables. Most useful to the housewife, however, are the final frozen-pack tables which summarize for each fruit and vegetable the method of preparation, type of container, and method of packing.

Starches and flours.—The quality of many cooked desserts depends greatly upon the thickening power of starches. Why is it sometimes difficult to get a smooth paste when starch or flour is used for thickening? Why does a pie filling sometimes refuse to thicken and a molded pudding fail to set? These are only a few of the questions investigators at the Illinois Station are attempting to answer in their starch studies which have been noted in previous reports. The observation that starches are seldom used in food preparation in the total absence of sugar, salt, and such ingredients as milk or fruit juices, both of which contain salts, led to a study of the viscosity, or slowness of pouring of starch pastes with or without added sugar and ordinary table salt. Wheat-starch paste was found to have a lower viscosity than cornstarch and the latter began to swell and increase in viscosity at lower temperatures, demonstrating why cornstarch rather than wheatstarch is usually used in cooking. When only as much sugar was added to the starch paste as would be used in a slightly sweet pudding there was a considerable increase in the viscosity of the starch paste heated to about 80°, but when as much sugar was added as would be the case with a very sweet pie filling or similar mixture the paste became much less viscous. The addition to starch paste of very small amounts of one of the salts present in milk, potassium citrate, increased the viscosity, showing that milk plays some part in the thickening of custards and milk puddings. The beneficial effects of small amounts and harmful effects of large amounts of sugars and salts on the appearance of starch-containing desserts was also shown by the ability of the cooked paste to gel. Both corn- and wheat-starch pastes containing 10 percent sugar held their shape well when turned out of molds after cooling, but those containing 60 percent of sugar, or not much more salt than might be used for seasoning, flattened out.

Some of the difficulties in starch cooking are thus shown to be due to the use of too much sugar or salt. Much of the responsibility for the quality of home-made cakes and breads rests with the miller and is beyond the control of the housewife. The contributions of the experiment stations to milling problems and baking technology are of indirect help, however, in so far as they result in improvement in blends and treatment of flour, in commercially baked breads, and even in new baking formulas which can be used in the home as well as the laboratory. At the Illinois Station a study of the effect of five different bleaches on the cake-baking qualities of a patent grade of soft-wheat flour made from certified Fulhio wheat showed that the bleached flours gave superior products to the unbleached as judged by home-baking standards, and that one of the bleaches improved the quality of the flour much more than the others. If atten-

tion is paid by flour millers to these findings, better products will be assured to the home cake baker as well as to the trade.

Housewives who have attempted to use honey in place of sugar in cake making have met with varying degrees of success. In a study at the California (Davis) Station to determine the conditions under which satisfactory cakes can be made with the replacement of some of the sugar in the ordinary recipes by honey, it was found that the natural acidity of the honey, which varies widely with different types, accounts for some of the trouble experienced. Star Thistle honey, which was the first one tested, may be used in a basic plain-cake recipe up to 50 percent of total sweetening if the amount of the liquid ingredient is adjusted, and in even higher proportions if the acid in the honey is neutralized with baking soda. The amount of honey that may be used will depend largely on the acidity, for too much soda will affect the flavor of the cake. Cakes made with honey have the advantage over cakes made with sugar in keeping moist longer.

Attention was called in the 1935 report on the stations to the altitude baking studies at the Colorado Station which have resulted in the derivation of an equation for determining the correct proportions of ingredients for an angel food cake which can be used at any altitude. An extension of this work to the mixture for sponge cake has shown that for this more complex mixture containing the additional variable fat, a single equation will not apply in all cases. The equations finally developed hold for specific amounts of egg and flour at each elevation and with sugar as the variable constituent.

In experimental bread-baking tests for flour quality factors influencing the oven spring of dough are considered of importance. As this is also true in the home baking of bread, some of the findings in a study at the Montana Station of oven spring of dough, as influenced by sugar, salt, and yeast, may be applied in home baking. Only one of the seven flours tested had the greatest oven spring when no sugar was used in the recipe. All of the others gave the best results with 1 percent of sugar. When as much as 5 percent of sugar was added, all doughs were sticky during the customary manipulation and the crusts were too dark. Moderation in sugar appears to be a good rule to follow in bread as well as custard making. With three flours at least 1 percent of salt was needed for maximum oven spring, while with others 1.5 to 2 percent of salt was required for the best results. The doughs without any salt and those with 3 percent or more of salt were all sticky during mixing. The action of yeast was retarded in doughs from four of the flours with as much as 3 percent of salt. Three of the flours gave the best oven spring with 1 percent of yeast and the others with 5 percent, although in several of these the sugar had become used up, as shown by too light a crust color, at the time the dough was baked.

Nearly all bread formulas are based on the use of compressed yeast, which is not available on isolated farms and ranches. For this reason a study was undertaken by the Wyoming Station to determine the best formula for bread making in high altitudes, using Wyoming hard-wheat flour and dried yeast cakes. During the course of this study it was found that even dry yeast cannot be kept for several months with good results and it was suggested that the poor quality of much of the bread baked in rural homes is due to using dry yeast

that is too old. Dry yeast is more or less dormant and must be allowed to stand for 14 to 16 hours either in a ferment or starch of potato flour and water or a sponge of flour, milk, and a little salt before mixing into dough. With Wyoming hard spring wheat flour better results were secured with the sponge than the ferment method. A temperature of 80° to 85° F. proved satisfactory for the fermentation of the dough, which was allowed to rise to three times its bulk in the first period and two and one-half times in the second and third periods.

See also page 30.

To encourage the use of whole-wheat bread in Wyoming rural homes the station also carried on baking tests with various proportions of white flour and whole-wheat flour of medium, fine, and coarse granulations. A light loaf could be made from the finer whole-wheat flour with the addition of 55 to 60 percent of white flour, but with cracked wheat more of the white flour was required. A somewhat lower baking temperature and longer time of baking were required than for white bread.

QUALITY IN NUTRITION

For many years the experiment stations have conducted research on the nutrition of farm animals—feeding tests to produce cows, pigs, and sheep of better quality and research on small experimental animals to determine what are the factors responsible for health and freedom from disease in livestock. Some of the findings in research on small animals are applicable to human beings as well as animals, just as some of the findings in small-animal research carried on in various places throughout the world for the primary purpose of improving the health of human beings has been found equally applicable to farm animals. However, until fairly recently, experiment stations have not been concerned with problems of human nutrition as studied on human beings as subjects aside from dietary surveys to determine the adequacy, according to the accepted standards of the moment, of the diets of rural people in their respective States.

The last few years have seen a growing interest in this field of research on the part of a few of the stations, as has been noted in previous reports of work at the Arizona Station on mottled enamel, a problem solved by work on both animals and humans; studies at Ohio University, the Wyoming Station, and elsewhere on the basal metabolism of human beings of different ages; the series of studies at the Oklahoma Station on the nutritional problems of pregnancy, and the extension of the work of the Wisconsin Station on nutritional anemia from rats and pigs to humans. Of even greater significance in showing increased interest in human nutritional problems is the development of three regional cooperative projects, each of which is participated in by several of the stations under formal memoranda of agreement.

The first of these cooperative projects, entitled "The Nutritional Status of College Women," is located in the North Central States, with participation by the Iowa, Kansas, Minnesota, Nebraska, and Ohio Stations and the University of Wisconsin. The second of these projects in the Northeast and the third in the Northwest both deal with vitamin C metabolism and requirements. In the former the

Maine, Massachusetts, New York (Cornell), and Rhode Island Stations are participating and in the latter, which was formally organized in October 1937, Oregon, Washington, and Utah Stations are already taking part, with the probability of two other stations joining.

In these three cooperative projects, already involving 13 States with others probably joining later, the subjects are women students at the land-grant institutions. Probably the majority of them are from rural homes. Consequently the investigations will show on a scale so large that the conclusions drawn from them will be generally applicable (at least in the region where the separate studies are being made) what is the present nutritional status of girls of this age from rural homes and along what lines improvement is needed. In the North Central States project, which is on a larger scale than the other two, the work covers basal metabolism, essential to determine the energy requirements of the diet and useful in detecting abnormalities in metabolism pointing to disturbances needing medical attention; blood studies, including among other things tests which will throw more light on the iron requirements of subjects of this age; complete dietary records to show what the girls are actually eating; and metabolism studies, necessarily in a much smaller number, to determine whether or not the freely chosen diets of these girls are adequate in such essential food constituents as nitrogen, calcium, and phosphorus. At the very beginning of the work various body measurements are taken which will be of help in interpreting the other data to be collected. The group of investigators at work on this extensive project have already discussed their preliminary findings, but nothing as yet has been published from the joint investigation.

Much of the important research on laboratory animals, chiefly the rat, for the ultimate purpose of solving human nutrition problems is difficult to understand until its final application in diet recommendations. In the experiment station research programs there are many investigations which give promise ultimately of being applicable to human nutrition, but which at present are in the stage of requiring faith and imagination to see their human application. Because of the magnitude of the nutrition research program with small animals, a single illustration only will be given of investigations still in the small-animal stage, another of investigations begun with small animals and now extended to human beings, and still another showing the logical development of research on a single problem through the laboratory stage, the application of laboratory discoveries to human beings, and finally the practical solution at least on a small scale of a problem of great significance in certain areas of the country.

Nutritional cataract.—Following the discovery about 2 years ago that mature or markedly advanced cataracts invariably occur in rats fed a laboratory diet containing excessively high levels of lactose (milk sugar) as the sole source of carbohydrate, the Massachusetts Station has continued the investigation in the hope of throwing some light on the cause of so-called senile cataracts in human beings. In the first experiment lactose was fed at the excessively high level of 70 percent of the diet. Later similar cataracts were produced in a much shorter time in rats fed a similar diet with galactose (the sugar formed on the break-down of lactose) as the sole source of carbohydrate at a level of 50 percent of the diet. When the amount of galactose was reduced still further to 35 and 25 percent of the diet, amounts corresponding

to the galactose which would be formed from lactose at 70- and 50-percent levels, again cataracts resulted in a very much shorter time than on corresponding amounts of lactose. These differences, together with the negative results obtained when other sugars (xylose and fructose) and starch were used in place of lactose or galactose, were thought to prove that galactose is the chief cause of this type of cataract.

The Massachusetts investigators next attempted to find out whether any other changes in the diet would either prevent or hasten the appearance of the cataracts. All sorts of changes were made without the slightest effect until it was found that a reduction in protein from the regular 15-percent level to a 5-percent level shortened the time of cataract development very noticeably, the effect being greater than an increase in the galactose level from 25 to 35 percent. This finding seems of particular interest in view of the fact that senile cataract develops at a time of life when the usual diet recommendations and common practice point to a lowering of the protein of the diet. However, the research workers on this problem are proceeding with caution and as yet are making no comparison with human diets.

Nutritional anemia.—The history of the discovery by the Wisconsin Station of the relation of copper to iron in the formation of hemoglobin and the prevention of secondary or nutritional anemia has been summarized in previous reports. With the proportion of iron and copper required for optimal hemoglobin regeneration in depleted rats now fairly well established, it has been possible to study the effect of other factors on hemoglobin formation. In a study at the Wisconsin Station of the effect of nine different proteins on the rate of hemoglobin regeneration in anemic rats supplied with adequate iron and copper, it was found that when the dietary protein was either qualitatively or quantitatively inadequate for growth hemoglobin regeneration was greatly retarded. Among the effective proteins were those of liver, casein, egg albumin, and soybean meal and the ineffective corn-gluten meal, wheat gluten, and gelatin.

With liver playing such a vital part in the treatment of penicious anemia, there has been some uncertainty as to whether its effectiveness in simple nutritional anemia is due solely to its iron and copper content or possibly to some other factors in addition. To answer this question the Wisconsin Station fed anemic rats various commercial preparations of iron, or iron and copper combined with whole liver or liver extracts, at levels sufficient to supply 0.5 milligrams of iron daily. As thus adjusted, the various preparations proved equally effective, showing that their hemoglobin-regenerating efficiency was due solely to their iron and copper contents.

During the course of a study at the Arizona Station of the hemoglobin-regenerating value of various foodstuffs, it was observed that hemoglobin regeneration was greater in the females than in the males fed at the same levels of iron intake up to 0.2 milligram daily, above which the difference between the sexes was less apparent because the iron intake was large enough to promote maximum regeneration in all of the animals. While at the time the Arizona investigators were interested in this sex difference primarily because it pointed to the necessity of using animals of one sex only in testing the hemoglobin-regenerating potency of any food material, more recent observations

afford an explanation of this difference between the sexes, which is of particular interest in view of the use which the female may be called upon to make of her iron reserves. Feeling that sufficient attention had not been given to the provision of plenty of copper to use up all of the iron reserves in the body of experimental rats when they are being prepared for anemia studies, the Arizona investigators supplied additional copper during the depletion period on milk and found that under these circumstances there was much less difference between males and females in their response to iron and copper feeding. This finding was thought to indicate that part of the sex difference previously noted was due to a greater store of iron in the female of the same hemoglobin concentration. Perhaps the lower hemoglobin levels of the blood of women than of men on the same diet is due to the need for greater reserve stores of iron by females than by males.

In the 1936 report of this series the preliminary results were noted of an extension of the Wisconsin anemia work to infants. In the complete report of this study the conclusion was drawn that anemic infants respond better to iron supplemented with copper than to iron alone. During periods of infection the administration of medicinal iron and copper was found to be ineffective. Recovery from infection must occur before iron and copper medication is of any value. Healthy well-fed infants with sufficient reserves of iron and copper were found to maintain an average level of from 11.5 to 12.5 grams of hemoglobin per 100 cubic centimeters of blood throughout the first 2 years of life.

On extending their studies to young college women, the Wisconsin investigators found that, unlike infants, anemic women of this age group responded as well to iron medication alone as to iron and copper. The subjects were chosen on the basis of two or three successively low hemoglobin readings, the average being 11.4 grams per 100 cubic centimeters of blood. In 40 women who were given 25 milligrams of iron daily in the form of ferric pyrophosphate plus 1 milligram of copper as copper sulphate, the hemoglobin values rose to from 12.69 to 13.69 grams, with an average of 13.23 grams per 100 cubic centimeters of blood, while in 35 women receiving iron alone the final values ranged from 12.85 to 13.49 grams, with an average of 13.15 grams per 100 cubic centimeters. In further work with college women, the conclusion was drawn that there are significant daily variations in the hemoglobin levels of normal healthy women, and that a range of from 13 to 15 grams, with an average of 14 grams per 100 cubic centimeters, may be considered as the average hemoglobin of healthy women 20 to 27 years of age.

Preliminary reports of a similar study of women students of the University of Illinois showed a predominance of values under 13 grams before any treatment and of values of 14 grams or more per 100 cubic centimeters after the administration of iron and copper in the same amount as in the Wisconsin study. This would indicate that the small groups of students examined were somewhat anemic. In view of the recent observations at the Arizona Station, it seems quite likely that not enough attention has been paid in considering the iron requirements of women to the demand of the female organism for additional iron for storage purposes.

59024—38——10

Mottled enamel.—The story of mottled enamel and the discovery by the Arizona Station of its cause in the fluorine content of the water has been reviewed in previous reports, but with no practical solution of the problem as far as concerns individual homes with a fluorine-contaminated water supply which cannot well be changed. The Arizona Station, not content with discovering the cause, without a practical remedy, for this disfiguring and destructive action on the teeth, has finally succeeded in developing a method which, at a not prohibitive cost, can be used in the home to free the water supply from fluorine, or at least reduce the content below the danger level. The method involves slow filtration of the water through specially prepared ground bones which take up the fluorine as the water passes through. As a practical test of the method, water from the high-school well in a community in Arizona in which all of the native inhabitants have typical mottled enamel, was filtered by gravity through a bottle containing 5 pounds of the prepared bone at the rate of 30 gallons per hour and the filtered water tested for fluorine at intervals. The water at the beginning contained 3.5 parts of fluorine per million, while the danger level is as low as 0.9 part per million. Fluorine tests made after 35 and 70 gallons had passed through showed a content of 0.1 part per million and after 105 and 140 gallons a content of 0.2 part per million, or still well below the danger level. Whether or not the method can be used on a large scale for municipal water supplies has not yet been determined, but it promises to be a godsend for home use.

Vitamin requirements.—While a great deal is now known of the vitamin content of foods, both relatively for the vitamins whose chemical nature has not been determined and absolutely for vitamin C which can now be determined by chemical tests, the exact requirements for human beings are still pretty much a matter of conjecture. Quite recently, however, tests have been developed for two of the vitamins, A and C, which give some indication of the stores of these vitamins in the human subjects being studied and offer promise of being useful in determining requirements. Although these tests did not originate in experiment station research, they are being used in several of the stations, particularly the tests for vitamin C which will constitute a large part of the research under the northeastern and northwestern cooperative projects on vitamin C metabolism (p. 9).

Vitamin A.—The test for the state of nutrition of human subjects with respect to vitamin A depends upon the fact that night blindness, in the absence of any other pathological condition of the eye, is due to insufficient vitamin A. There are now on record many instances of night blindness interfering seriously with ability to drive a car after dark or carry on any work in poor illumination that have been cured by large doses of vitamin A. To detect night blindness an instrument known as the biophotometer is now being used, by means of which the response of the eye to the change from darkness to bright illumination and vice versa can be tested. While there is not complete agreement as to the degree of dependence which can be placed on the test, and it cannot be used for very small children, some rather significant findings have been obtained with the use of this instrument.

One of the first experiment stations to make use of the test was that of Illinois, where the earlier form of the instrument, known as a Birch-Hirschfeld visual photometer, was used in tests on 20 children from low-income families to determine whether carotene, the plant precursor of vitamin A, is as effective as halibut-liver oil in supplying the vitamin A needs of children. In the first tests 17 of the 20 children gave low results, indicating a deficiency in vitamin A. Four of these recovered after from 14 to 26 days on a daily supplement of carotene furnishing 5,000 International units of vitamin A, 3 others showed some degree of improvement, and 10 no improvement during treatment, which varied in length from 7 to 29 days. Many of the children were changed from carotene to halibut-liver oil furnishing comparable amounts of vitamin A but with no difference in results. When the vitamin was increased to 10,000 International units daily in the form of halibut-liver oil, prompt and rapid recovery occurred. As this large amount of vitamin A was given only in the form of halibut-liver oil, there was nothing to indicate that carotene is less effective than halibut-liver oil when administered in amounts furnishing the same number of vitamin A units.

The newer form of photometer known as the biophotometer has been used in an extensive investigation at the Pennsylvania Station of the nutritional status with reference to economic status of all the individual members of entire families. A preliminary unpublished report states that persons of the highest income levels (including families of annual cash income of $5,000 a year or more) gave significantly higher average readings in the photometer tests than those of all the lower income groups. Although no significant differences were found among these lower income groups taken as a whole, there was found to be a definite relationship between the amount spent for food and the readings, indicating that in general the greater the amount spent for food, the higher the vitamin A intake. A comparison of the dietary records of 50 families showing high vitamin A intake and the same number showing a low intake with the photometer readings of the individual family members showed significantly higher readings for the first group than the second, thus confirming in a general way the value of the test as an indication of satisfactory or unsatisfactory vitamin A nutrition.

In another experiment conducted by the Pennsylvania Station investigators on groups of school children before and after treatment with various vitamin A concentrates, it was found that the children receiving vitamin A treatment in the form of large doses of carotene daily during the winter gave significantly higher photometer readings in the spring than a control group receiving no additional vitamin A.

A preliminary report from the Georgia Station states that of nearly 200 children from the first grade through the sixth who were tested with the biophotometer during the winter months almost half gave readings which were border line or subnormal, while after halibut-liver oil treatment of a large number for a period of 3 or 4 weeks, the values for most showed marked recovery.

In a study still in progress at Purdue University, La Fayette, Ind., on vitamin A storage in young college women, the biophotometer readings on about 100 subjects before vitamin A treatment gave relatively low values for about 20, and definitely higher values for

two subjects (who had been taking vitamin A concentrate), with the others in the range of normality. The subjects with low initial values were then paired, one of each pair receiving no supplement and the other three halibut-liver oil capsules daily. Although there were individual differences in response, the group receiving no supplements showed no consistent improvement at the end of 5 weeks, while the others showed improvement.

From these tests, the biophotometer appears to be of some use in detecting vitamin A deficiency, but as yet a satisfactory method has not been perfected for its use in determining actual requirements.

Vitamin C.—Three methods are in use for determining the body's store of vitamin C—(1) the capillary fragility method, which measures the strength or weakness of the blood vessels either by direct or positive pressure with an instrument similar to the one used by physicians in determining blood pressure, or by indirect or negative pressure with a vacuum cup device, (2) urine tests, which measure vitamin C excretion, and (3) blood tests, which measure the content of the vitamin in the blood stream. The first of these tests has received some attention at several of the experiment stations, particularly Maine, New York (Cornell), and Utah. Probably the most extensive work at any of these stations has been done at the Utah Station where the work was started in an attempt to determine whether any relationship exists between vitamin C deficiency and dental caries. Although no such relationship is apparent as yet, the test as applied to about 400 rural children has shown a tendency to increased capillary fragility in the spring as a sequel to reduced vitamin C intake during the winter.

The capillary fragility test, by the positive pressure technic, has also been applied by the Utah investigators to more than 250 college women students. Of these, 5 percent gave results indicating subnormal vitamin C, while a little over 9 percent were border-line cases. When vitamin C from natural sources, and synthetic or manufactured vitamin C were given to a few subjects who had shown low values, there appeared to be a better response in the capillary test to the natural source of vitamin C than to the synthetic vitamin. If these preliminary findings should be confirmed by further work, it would suggest that capillary fragility is not a result of a deficiency of vitamin C, but of something so closely related to it as to be present in most natural sources of the vitamin. It has already been suggested by Szent-Györgyi, who received the 1937 Nobel Prize for medicine for his research on vitamin C, that such a closely related vitamin does exist.

Fortunately most American diets are not so low in vitamin C or the closely related vitamin P as to make the capillary fragility test for extreme deficiency a practical one in this country. The second of the tests mentioned above is the one in most extensive use in the cooperative research projects in the Northeast and Northwest. Results which have been reported from an institution in each of these regions will serve as an illustration of what can be hoped for when the work develops on the large scale made possible by the coordinated attack on the problem.

About 4 years ago some English investigators discovered that vitamin C is excreted in the urine in amounts varying with the individual

and with the diet, massive doses of vitamin C being followed sooner or later by large increases in the amount excreted. Since then much work has been done all over the world to see whether this test can be used to determine vitamin C requirements. In a study recently reported from Washington State College as preliminary to the more extensive investigation which is now being carried on under the northwestern cooperative project, the amounts of vitamin C excreted daily in the urine of seven college women were determined for varying periods of time with these results.

Two subjects, receiving little or no fruits or vegetables in their diets, excreted 10.58 milligrams and 14.36 milligrams daily; two subjects, whose diets included some fruits and vegetables, excreted 29.32 milligrams and 23.69 milligrams daily, while three subjects with high intakes of fruit juices, salads, and vegetables excreted 42.64 milligrams, 60.23 milligrams, and 83.72 milligrams daily. "Saturation" tests of one massive dose of 600 to 800 milligrams ascorbic acid showed an excretion of 30 percent of the dose only in subjects who were previously excreting 60 miligrams daily while on their regular diet.

These results might be taken as an indication that 60 milligrams of vitamin C daily is the requirement for women of this age, but it is realized by all who have been working along these lines that, as stated in the report of the Washington study, "more subjects, both healthy and suffering from various diseases, need to be studied before any definite statement can be made as to quantitative requirement under varying conditions."

Urine tests are being used by investigators at the New York (Cornell) Station in an attempt to determine vitamin C requirements according to the following plan: Normal adult women are given 200 milligrams of vitamin C as ascorbic acid daily until saturated, as shown by the recovery in the urine within 24 hours of at least half of a test dose of 400 milligrams. Then the subjects are put on a diet containing almost no vitamin C, but supplemented with a small amount daily of the pure vitamin. After several days a large test dose is again given and the response to this is compared with the response after known saturation has been reached. If the response is less than 50 percent of the test dose the experiment is repeated, using a somewhat larger amount as a daily dose. Finally a point is reached when a satisfactory response follows the test dose. With the few subjects thus far studied, a 25-milligram daily dose, which many have considered to be the minimum daily requirement for adults, has been quite insufficient and amounts varying from 50 to 85 milligrams a day have been required.

With the remarkable discoveries which are continually being made in nutrition research and the extravagant claims of much of present-day food advertising, it is often difficult for the consumer to distinguish between propaganda and legitimate claims. The Massachusetts Station has recently rendered a good service to the bewildered consumer in a bulletin (No. 342) which summarizes "information, decisions, and criticisms by recognized authorities concerning nutritional and therapeutic claims in food advertising as well as faulty concepts and notions regarding foods and nutrition." As a final aid a list is given of 10 reliable reference books, the latest editions of which can be depended upon to give up-to-date information on the rapidly growing science of nutrition.

QUALITY IN TEXTILES

Factors affecting the quality of cotton and wool fabrics begin with the fibers from which the fabrics are woven and go on through the manufacturing process to the treatment which they receive in wear and cleaning. The first and last of these factors are receiving attention in a few of the experiment stations. Silk and rayon textiles are also being studied for the factors which in the final material affect wearing quality.

Cotton.—The physical characteristics of cotton fibers are receiving much attention at the Texas Station. The necessity of making many tests of fibers has led to the development in the textile laboratory of the station of improved methods of determining strength and fineness of the fibers. For the former a tiny bunch of fibers is carefully combed, cut to a definite length, and weighed and then fastened between strips of drafting tape such as is used by architects. It is then a simple matter to measure the strength of the fibers by breaking the prepared sample in an ordinary breaking strength machine. Fineness of the fibers can be measured satisfactorily, taking microphotographs of cross sections of the fibers at a high magnification and measuring them with a planimeter. For a single sample of cotton at least 250 measurements were found necessary for accurate results. These studies are mentioned simply to show how very delicate and time-consuming are methods of fiber analysis.

Fabric analysis, although simple in comparison with fiber analysis, requires considerable time and for best results should be done in a special laboratory in which temperature and humidity can be controlled. Several of the experiment stations now have such laboratories, among them Kansas and Minnesota. The effect of bleaching processes on cotton sheeting was tested at the Kansas Station by analyzing several brands of bleached and unbleached sheetings for thread count, breaking strength, kind and amount of sizing, weight per square yard, and whiteness before and after 20 launderings. Some of the unbleached sheetings were subjected to a bleaching process before each laundering until they matched in whiteness the commercially bleached sheetings of the same brand. At the end of the experiment the unbleached fabrics which had received no treatment except laundering were stronger than the bleached ones and those which had been bleached and laundered had about the same strength as the commercially bleached sheetings. However, after several months' storage in a dark closet the commercially bleached samples were still white, while the others had become yellow. To the housewife this means that if whiteness is the quality most desired in sheetings, commercially bleached ones should be purchased, while if strength and consequently longer wear counts for more than appearance, it is best to buy unbleached sheeting and not attempt to hasten the natural bleaching that comes with successive launderings.

Housewives who hesitate to make use of power laundries for fear of greater wear will be interested to learn that in another study at the Kansas Station the power laundry was found to be less destructive than home laundering methods on three-fourths of all cotton materials tested. While the one power laundry involved in the study handled the white clothes more satisfactorily than the home laundry,

it did not prove as satisfactory for colored clothes as there was greater change in color than in the same materials laundered by home methods. The materials in the Kansas study were tested after 20 launderings.

In a special study at the University of Missouri of the effect of several commercial and home laundry methods on five unsoiled plain-weave fabrics of the muslin variety, the materials were laundered 100 times with tests after 1, 5, 15, 30, 45, 75, and 100 launderings. Some of the samples were not ironed and others ironed at each laundering with an electric hand iron or an electric rotary iron. The results seem to indicate that the commercial washing methods caused less decrease in the strength of fabrics during the first 15 launderings but more thereafter than did the home methods used. The amount of shrinkage was similar with all methods of laundering. In the commercial process, ironing was responsible for much of the decrease in strength fillingwise. In the home method, after the first few launderings the washing procedure appeared to be more responsible for the strength loss and other changes.

In other studies at the Missouri Station the effect of wear as well as laundering has been determined. Durability tests on 24 nightdresses made from 5 cotton muslin fabrics and laundered after each three wearings and the same number laundered without wearing indicated that the effects of body wear were greater than those of laundering. The signs of deterioration due to wear were greatest under the arms and across the shoulders of the garment and those of laundering greatest along the folds and the edges of the heavy seams. Through the cooperation of homemakers and students, samples of 33 new fabrics and the same fabric discarded because of wear were analyzed. Percales, nainsook, batiste, and voile were the fabrics most frequently represented, although there were a few others. In most of these fabrics the filling (crosswise) strength was much lower than the warp (lengthwise) strength in the new fabrics and also decreased more during wear.

This raises the question why such fabrics are made with the warp threads so much stronger than the filling threads when both the appearance and the strength of the worn-out fabrics show the wear to be much greater fillingwise than warpwise.

The housewife who does a good deal of home sewing would be greatly benefited in the selection of material if she could be given some information on the strength warpwise and fillingwise of the material and other factors affecting wearing quality. The information obtained in this Missouri study explains why the particular fabrics wore out as they did. This and a much more extensive investigation along similar lines to be noted later will make the housewife aware of the qualities textile materials should possess for service, but until such information is available at the time of purchase she will not be able to make the best selection.

A recent investigation at the Arkansas Station contributes the type of information noted above as being greatly needed for a group of cotton materials used extensively for children's clothing. These included six samples of nainsook costing from 11 to 50 cents per yard, seven of broadcloth from 11 to 65 cents, and two of suiting 25 and 29 cents per yard, respectively. The fabrics were purposely selected with

a wide range in cost in order to see if price is a good guide to quality. As brought out in this study—

quality is a broad term that may cover many characteristics of a material. Each particular fabric has its best use. Fine nainsooks for babies' clothes will not serve satisfactorily as material for little boys' suits, yet nainsook and suiting may give excellent service for certain garments. No one fabric is superior to all other fabrics made of the same type of yarn and no one test can be a satisfactory measure of the service that any material may give.

While the most expensive fabrics did not have the greatest tearing and breaking strength, they were lighter in weight, thinner in texture, smoother in finish, and more even in yarn and weave and showed more nearly balanced fabric elongation (or stretching) in the warp and the filling. The low-priced fabrics showed excessive stretching in the filling threads, an undesirable feature from the standpoint of the shape of the garment after laundering and wear. While much of the information obtained in this study is untranslatable to the housewife, the accumulation of data along similar lines will after a time make it possible to set up standard specifications for such goods as a basis for grade or descriptive labeling.

Two types of fabrics in common use for nurse's or house uniforms, poplins and broadcloth, were studied in the textile laboratory at the Minnesota Station to determine which type of material gives the greater service. The poplins proved more satisfactory as a class than the broadcloths because they showed less shrinkage, were more durable as judged by the customary strength tests, and also showed less variability among the various physical characteristics.

Silk.—A garment representing a considerable outlay, with all too little information available about wearing quality, is the "silk" slip. A study at Kansas State College of the effect of actual wear, laundering, and aging on silk slips purchased from six different companies showed that the material of which the slips were made varied greatly in thread count, balance of thread, weighting, tensile strength—all factors affecting quality. The amount of wear, as shown by the same tests after the slips had been worn a given number of hours (525–1,000), varied little in the better slips worn by different individuals, while it varied greatly in slips of poorer quality. This probably means that it is more essential for a woman who is "hard on her clothes" to buy a better grade of slip than for one who perhaps because of a better figure is "easy on her clothes." The deteriorating effect of age was much greater in the more heavily weighted slips. The slips which had been laundered four or five times per 100 hours of wear showed earlier deterioration than those laundered only once in the same length of time.

With laundering an important factor in the wearing out of silk slips, it is of interest to note that in a study in progress at the Minnesota Station on the wearing qualities of silk crepes, such as used for underwear, some evidence is being obtained that the new type of detergent now coming into use as substitute for soap may be less harmful than even a neutral soap for washing silk fabrics. Work is in progress at the Montana Station to compare the effect of the new type of detergent and soap on silk hosiery.

Performance during wear of silk and cotton fabrics.—Realizing that it is only on the basis of large numbers of comparisons of analyses of clothing fabrics with actual performance during wear

that recommendations can safely be made to the housewife as to what to buy to meet certain needs and to the producer as to what qualities are desired for specific purposes, a group of extension and research workers in the Northeastern States in 1935 organized a cooperative project in which six States are now cooperating. The project consists in laboratory analyses, all of which are being done at Pennsylvania State College, of samples of fabrics purchased for women's and children's dresses to be made in the home, and of records kept by the women who make the dresses of the length of time they are worn and the number of times laundered or cleaned. When discarded the garments are sent to Pennsylvania State College for inspection, and the records kept by the women are compared with the life expectancy of the garment as predictable from the analysis of the fabric. To illustrate, two of these predictions taken from the records are as follows:

For a cotton print—

the color fastness of this type of material may be expected to be good except when it is rubbed by another material either wet or dry. The texture is firm, and the material should show durability in the lengthwise direction. It may tear if strained too much in the crosswise direction. It may be expected to shrink about 1 inch per yard in the lengthwise direction and 1½ inches per yard in the crosswise direction. The fabric will probably appear somewhat thinner after it is washed because the sizing is removed.

For a weighted silk—

the color fastness of this fabric may be expected to be relatively poor, except to drycleaning and dry pressing. The strength in the lengthwise direction is good but it is very poor in the crosswise direction, especially when wet, since, in addition, the fabric is heavily weighted. The durability is apt to be unsatisfactory also. Pulling at the seams may show under little or no strain.

The home dressmakers who are taking part in this cooperative project will probably be made very conscious of the need of informative labeling of textile fabrics and perhaps repeated requests for such information will do much to persuade the manufacturers of the wisdom of giving reliable information as to the nature of the goods they wish to sell.

QUALITY IN HOUSEHOLD EQUIPMENT

Whether it be a kerosene, gas, or electric stove, an electric iron, a vacuum cleaner, or utensils large and small for which the housewife wishes the best value for the price she can pay, advice is ready for her in recent experiment station publications.

Kerosene stoves.—Preliminary comparative studies have been made by the Maine Station on five kerosene stoves representing three types of burners—the long-chimney type with wicks, the short-chimney type with wicks, and the wickless, short-chimney type with asbestos lighting ring. Four of the stoves had built-in ovens, of which two had rock-wool insulation, one a single layer of asbestos paper for insulation, and the other no insulation.

According to the studies thus far made, there is opportunity for considerable improvement in the construction of kerosene stoves. The spacing of the burners was such that only two of the stoves could accommodate the use of two utensils with maximum top or bottom diameter of 10½ inches, while with two of the stoves utensils with a 9-inch diameter were the largest that could be placed at the same time on adjacent burners. Another objection to the stoves examined

was the inability to regulate the burners to low heat. This results in unnecessary waste of heat which is undesirable because of overheating the kitchen as well as necessitating the use of excessive amounts of water in cooking.

Gas and electric ranges.—A circular (No. 55) of the Nebraska Station, based on the extensive investigation of the merits of various types of gas ranges in the market noted in the 1936 report, answers most of the questions which any prospective purchaser might ask and gives a rating chart which can be taken to the store and checked in comparing the relative merits of different models. The problem is simplified, according to this circular, by basing the choice upon at least three factors which, ranked in order of importance to the buyer, are price, performance, and construction. The approved seal of the American Gas Association indicates that the model has complied with the requirements of the association's testing laboratory in performance and construction and also in safety. Since the range represents a piece of equipment that will be used for many years in the ordinary home, some thought should be given to its appearance. An enclosed cooking top of adequate size to accommodate several large-sized utensils with lightweight grates which make little contact with the top and small burners set very near to the bottom of the pan means lower operating cost. Because most people cooking with gas tend to use a higher flame than is necessary, a range equipped with a simmer burner has an advantage, particularly for long-time cooking processes. The convenience of the automatic lighter is worth the slight additional operating cost.

The best oven is well insulated, has interior dimensions of about 16 inches wide, 14 inches high, and 19 inches deep, with adequate rack space and is equipped with an accurate automatic heat control so that it is possible to maintain a temperature of 250° F. for at least 3 hours. While the choice of the model depends upon the individual's taste and the arrangement of the kitchen, the interested housewife is reminded that the biggest advantage of the console model is that no stooping is required to put food in and remove it from the oven. In the table-top model the oven is located below the cooking surface. The Nebraska Station has found that in the majority of cases the higher priced ranges have much heavier sheet enamel and are, therefore, somewhat sturdier than the cheaper ranges.

When there is a choice between electricity and gas for cooking, there are many points to be considered in addition to the obvious one of the relative expense of the two fuels in any particular locality. A comparative study on electric- and gas-range ovens conducted at the Indiana Station reveals that the electric ovens require less time for preheating and more energy than do the gas ovens and they also show better heat retention. In other words, cooking continues longer after the heat is turned off in the electric ovens than in the gas ovens. Although both gave satisfactory results, the gas ovens maintained a more even temperature during long heating periods. That it represents economy to use the oven for more than one product when it is heated is established by this study, which shows that in baking periods of less than 1 hour the cost to preheat an electric oven is generally greater than the actual baking cost.

Approaching the same question from a different angle, investigators at the Iowa Station have determined the desirability of baking

some food products by starting them in cold and in preheated ovens. They baked plain and angel food cakes, baking-powder biscuits, yeast rolls, and cream puffs by both methods, using ovens in two gas, one kerosene, and three electric ranges. The cakes baked in the preheated ovens scored considerably higher than those started in the cold ovens. Baking-powder biscuits baked in preheated electric ovens were preferred by the judges, but in the gas and kerosene ovens the products were equally desirable regardless of the method of baking or the type of range. The cream puffs baked equally successfully from a cold and a preheated start. The differences in fuel consumption in the two methods of baking were considered practically negligible, as were the differences in time required in the gas and kerosene ranges. However, there was a saving of time when the foods were baked in the preheated ovens of the electric ranges.

In many a rural home to which electric power has been made available through the development of power lines, there is little left for the purchase of desired equipment after the electrical installation and wiring have been paid for. With this in mind, the Virginia Station, with the cooperation of the Tennessee Valley Authority, has investigated the possibilities of developing low-cost electric cooking equipment. Complete tests were first made of inexpensive electric hot plates found on the market, with the conclusion that they are far from durable. None of the stoves lasted as long as 200 hours, although one burner of a two-burner stove was still usable when the tests were stopped. There was little to complain of in the structure of the stove or the units, most of the failures being due to the switches and wiring. In view of the low cost of these hot plates, which ranged from 98 cents to $4.95 in price, it was felt that the duration of service might be all that could be expected, but that there would be little satisfaction in buying a cheap stove of this kind except for some special and temporary use.

Turning their attention next to the manufacture of durable and serviceable electric stoves, the Virginia Station investigators found that very satisfactory models of the hot-plate type could be made at a cost of about $4.50 for the two-burner size and about $6 for the three-burner size if materials alone were considered. The station has prepared working specifications (B. 310) for the construction of such a stove of the hot-plate type, and also of a complete electric range. Construction of the latter is not recommended, however, unless there is available a shop with complete manufacturing facilities.

A unique feature of these electric stoves is the abandonment of the rather expensive rotary three-heat switch. Very satisfactory results were obtained by dividing the burner element into two parts of different wattage and wiring to each a single pole toggle switch. This method was also followed in electrifying old kerosene stoves and even cheap-type kerosene ovens.

An old kerosene stove stripped of its burners and excess parts and then supplied with electric units and switches is apparently the best low-cost electric stove available. It has advantages with respect to height, quick assembly, and appearance over the hot-plate type of stove and costs no more.

The cost of the material for such a reconstruction, allowing $1 for the cost of an old kerosene stove, is estimated at $7.20. After the old stove has been made ready for wiring, only about one-half day of a mechanic's time is required to electrify it. Similarly, the

cost of materials for an electrified oven is estimated at $4.75 if $1.95 is allowed for a new oven of the kerosene-stove type.

The method of installing variable wattage elements in an oven is thought to have considerable merit in the uniformity of temperature which can be maintained. In the cheaper ovens the most efficient use of the electric current was not attained, but experiments with the better grade of commercial ovens indicate that the energy consumption will compare very favorably with the present method of thermostat temperature control.

Cooking utensils.—In further study at the Iowa Station of the relative efficiency of different utensils for surface cooking, considerable information was obtained on the efficiency of different types of surface units in the electric range as determined by the temperature distribution over the under surface of cooking utensils and the length of time required to bring a given amount of water to boil and to complete certain short-time and long-time cooking processes. The distribution of temperature over the surface of an electric unit was found to be fairly uniform with a slightly lower temperature at the outer edge. Both from a cold start and when preheated the enclosed unit required the least time, the open, embedded, and enclosed labyrinths slightly longer, and the cone-reflector type considerably longer time. It will be remembered that in the gas range the enclosed unit was also more efficient than the open. As for the utensils, which were made exactly alike—2-quart capacity, medium-weight, straight sides, flat bottom, and tight-fitting lids of copper, aluminum, and enamelware, all were practically equal in efficiency. A black-bottom finish tended to increase to a very slight degree the cooking efficiency of the aluminum pans, but did not increase the efficiency of the enamelware utensils.

Further guides for the purchase of surface-burner utensils for electric ranges are given in the technical report of the investigations at the Maine Station noted in the 1936 report on the stations. Black bottoms on aluminum or other polished metal pans were found to reduce time and cost of heating and boiling when used on cone, open, and tubular units, but if electricity is relatively cheap and the utensils have a rough-bottom finish, the extra cost of the black-bottom utensils is not warranted except in the case of the cone unit. With closed and ring units a black bottom in a utensil does not reduce appreciably the cost and time of heating. The value of a cover in reducing water losses depends upon the amount of heat being applied. A cover may be essential if medium or low wattage is used and is most essential for a wide pan even when it is used on the high heat of a 1,000-watt unit. A triplicate set of saucepans small enough in diameter to use on a small unit is more economical than single pans on three such units, but one so wide that a larger high-wattage unit must be employed may be no more economical than carefully controlled cooking in single pans. A pressure cooker or a well-built large saucepan may be used in place of a "waterless" cooker.

In a study at Kansas State College of the effect of the material of the pan on the temperature for baking and tenderness of angel food cake it was found that the cakes baked at the same oven temperature for the same length of time in enamel and glass pans showed a greater rise of temperature within the cake than those baked in aluminum and tin pans and had a much browner crust. The cakes baked in the enamel pans were also much tougher. This means that a somewhat lower oven

temperature and shorter time of baking should be used for cakes baked in enamel or glass pans than in tin or aluminum. This is probably a good general rule to follow in baking.

Vacuum cleaners.—One point which has been given comparatively little attention in the selection of a vacuum cleaner from the two main types of suction and suction with motor-driven brush is whether or not different types of rugs are cleaned more efficiently by cleaners working on different principles. A study at the Washington Station of nine vacuum cleaners operated on rugs of three types—axminster, wilton, and velvet—showed that the three types of rugs are very similar in their cleaning characteristics, but the cleaners using suction with motor-driven brush removed approximately one-third more dirt in a given time than those using straight suction. The amount of nap removed with the dirt varied with the individual cleaners and type of rug, but the wearing action as thus measured was considered to be very minor as compared with the wear of normal use. All but one of the slower cleaners tested cost less than $50, while the faster ones ranged from $50 to $80. The price alone should not be accepted as an indication of the efficiency and durability of the machine, but if the housekeeper's time is a factor to be considered, the additional cost of an efficient machine of the faster cleaning type is worth considering. After a vacuum cleaner of any type has been purchased and put into use, the cleanness of the inner surface of the bag is one of the most important factors to consider. In tests made in homes the Washington investigator found good cleaners giving very poor service simply because the bags were not thoroughly cleaned after use.

Electric irons.—The electric iron is one of the first appliances purchased when electricity becomes available in the rural home. So many improvements in design, durability, and efficiency have been made in new models that in homes where models of 10 or more years ago are still in service it may be economy to discard them and make a selection from among the many models now on the market. To help the housewife in the selection of an electric iron, whether it be the first or a replacement, the Virginia Station conducted a series of tests on about 20 well-known makes and models of electric irons now on the market. The report of these studies (B. 307) is a useful guide for the purchase of an electric iron.

In the advice given by the Virginia Station, it is stated at the outset that "to get an iron of long-time usefulness and dependability the price that will have to be paid will range between $5 and $9. Cheaper irons than this are not likely to give entire satisfaction." The new lightweight irons are entirely satisfactory, although 3 pounds is about the minimum weight for durability. In most cases low wattage (550–660) irons do not produce satisfactory ironing temperature. A 1,000-watt iron is recommended as best for regular and continued household use. The iron should be provided with thermostatic control, preferably marked with names of the material for which specific temperatures are suitable instead of high, medium, and low, and with an "off-setting" to serve as a switch. A permanently attached cord eliminates connection trouble particularly if the "off" is used as switch and the cord disconnected at the wall receptacle when not in use. Other features to be considered are some device for keeping a hot iron from scorching the board when tem-

porarily out of use, a well-insulated, well-shaped handle, beveled edge and sharp-pointed front, and a good appearance. As an indirect aid to the purchaser, the bulletin contains suggested standard specifications for electric irons which, if adopted by the manufacturer and indicated on the iron by a distinctive emblem, would serve as an indication and guarantee of first-grade quality and performance.

WORK CENTERS AND WORKING SURFACE HEIGHTS

Even with the best selection of household equipment the work which is done with it may be rendered inefficient by poor arrangement and placing. In a few of the experiment stations some work is being done on this rather neglected phase of research on problems related to the home.

Kitchen arrangement.—The results of a survey made by the Indiana Station of nearly 800 rural kitchens in the State showed that they vary in size from 6 by 7 feet to 24 by 24 feet, and that many are inefficiently arranged and inadequately equipped. Feeling that, "since farm homemakers spend an average of 54 hours a week in homemaking activities, the kitchen should receive more thought and attention when planning the home than any other room," the Indiana investigators selected a floor space 12 by 15 feet long as typical of the majority of Indiana rural kitchens and studied various ways of arranging in the space the equipment found in most kitchens. Each arrangement was tested by carrying out several typical tasks and noticing the number of steps involved. Some of the suggestions made as a result of this study could probably be followed to advantage by many a housewife in rearranging her kitchen. In a well-equipped and well-arranged kitchen the housewife should be able to start at the storage center and carry through the meal preparations to the final serving in the dining room with little retracing of steps or crossing from one work space to another. In a long narrow kitchen the equipment should be arranged around the end of the room, while in a square kitchen an L-shaped arrangement is more efficient. Sufficient light should be available at all work centers.

Standards for working-surface heights.—The saving of steps is one way of reducing fatigue in household tasks; another is to have all working surfaces at the correct height for the individual housewife. In order to supply some of the information required for setting up standards for working-surface heights which will meet the requirements of the average woman, investigators at the Oregon and Washington Stations recorded certain body measurements and preferred surface heights for various household activities of 312 Oregon and 250 Washington women, most of whom had homemaking as a full-time occupation. As judged from the data obtained, the average homemaker prefers a sink set so that its floor is 32½ inches above the floor of the room, a work table for mixing or beating 32 inches, an ironing board 32½ inches, a serving table 24 inches, and a cutting table 35½ inches above the floor. The variations of individual preferences from these average heights were surprisingly small. Two-thirds of the women tested chose work-table heights between 32 and 33 inches, beating heights between 30 and 33 inches, and dishwashing and ironing heights between 31 and 34 inches. Preferences as to cutting heights varied to a greater extent, but more than half of those making the test chose heights between 34 and 37 inches.

The differences in preferred heights for various tasks are explained from the different postures required. The fact that the majority of women, although varying considerably in height, were satisfied with the average heights, was explained through the discovery that although the range in total heights was more than 16 inches, there was a much narrower range in distance from the hands to the floor. The women selecting working heights fairly close to averages had wrist heights within plus or minus 1 inch of the preferred levels. When the working-surface heights selected by trial as most comfortable were compared with the actual heights of the same surfaces in the homes of the women taking part in the study, it was found that the differences were most marked in the heights of the sink and the cutting table. The average woman chose a sink 3.5 inches higher than that of her sink at home and a cutting table about 5 inches higher than the dining table which is often used for cutting. The home equipment was more often too low than too high for rolling pastry and too high rather than too low for beating.

The body measurements, which were a part of this study, were taken to determine average values for dimensions, based on eye level, standing and sitting, and for sitting arrangements for various tasks. In publications from the two stations (Oreg. B. 348 and Wash. B. 345), which give the complete report of this study, the average dimensions of various space units and equipment have been tabulated and form a useful construction guide.

QUALITY IN FAMILY LIVING

The proper selection and use of all available material resources, such as have been discussed in the previous sections on quality in foods, textiles, and equipment, play an important part in determining the quality of family living. This requires wise management by the farm housewife of the resources of the farm in cash income and goods and oftentimes the supplementing of the all too small cash income by enterprises of her own. Other equally important factors may be grouped under the general heading of family relationships, the intangible factors which make or mar family living. The experiment stations are investigating both the tangible and intangible factors which affect the quality of family living.

Contribution of housewife to family income.—The contributions which the farm housewife may make to the family income are generally considered simply as the cash which she may contribute to the family purse through the sale of farm products, unless she is engaged in some enterprise unassociated with the farm. In a study at the Oklahoma Station of the contributions to the family income during a single year by housewives on wheat, cotton, and diversified farms in the State, the contributions considered included not only the cash income from enterprises managed by the housewife, but also the money released when she contributed products for the family living which otherwise would have to be purchased, and the money released by her labor which otherwise would have to be hired. This does not include the ordinary homemaking and housekeeping activities, but the extra work quite outside the management of the home. For making the calculations where actual cash was not involved, the values of products used by the family were based on Oklahoma farm prices, and of labor at 15 cents per hour.

For the more than 150 housewives from whom records were obtained, the average net cash contribution to the family income was $168, the calculated contribution to the income of home or farm producing goods $54, and the contribution from labor saved $69. While the first of these figures is probably the only one to afford any satisfaction to the housewife, and perhaps the rest of her family, the other two should be taken into consideration as being just as much of a contribution as actual cash sales. The largest single cash contribution made by a housewife on a diversified farm was $1,258, on a wheat farm $1,887, and on a cotton farm $1,075. The dairy enterprise (butter and cream) was the one most commonly engaged in, followed by the poultry enterprise (stock, cockerels, broilers and fryers, and eggs), and then by the garden enterprise which, as would be expected, was much more profitable on diversified than on wheat farms and still more so than on cotton farms.

Numerous other enterprises were engaged in by various housewives, but most of these did not afford opportunities for large returns. Success in any enterprise, but particularly in the three involving farm products, depended largely upon the initiative, interest, and hard work of the woman.

The women who were most successful in any of the enterprises were those who were able to produce a well standardized product regardless of the effort necessary, and who supplied a steady output so that customers would not be disappointed. Regardless of all efforts, the woman had to be alert to her best market.

In rural communities close to urban centers, as is the case in Rhode Island, the housewife may have a part- or full-time job outside the home and yet attempt to be a homemaker. What effect does this have on the quality of living in the home? The Rhode Island Station has made a special study of the underlying causes and resulting conditions of such employment among over 600 rural women in one county of the State. Although satisfactory reports of cash income were secured from only about half of the cooperating women, they showed a weekly average of $17.79, a sum which, if added to other sources of income of the family, could not help but raise the standard of living in the group and probably of the community.

While most women in the Rhode Island study gave more than one reason for working outside the home, approximately 85 percent listed necessity as the main reason and 33 percent worked to obtain luxuries such as electrical equipment and washing machines. To 7.7 percent it served as an outlet for surplus energy, 4.2 percent worked for financial independence, 1.8 percent to escape housework, and 10.4 percent to pay for the home, help relatives, educate children, or for other miscellaneous reasons. The following types of work were engaged in: Industrial, 33.6 percent of the group; domestic, 17.3; commercial, 17; professional, 13.6; boarding and lodging, 11.1; homecraft, 5.3; agricultural, 1; and miscellaneous, 1.1 percent.

A survey of the equipment in the homes showed that a large proportion had electricity and some were very completely supplied with modern equipment. About 60 percent of the income-earning homemakers bought at least three-fourths of the clothing for their families and about one-half bought all of the bread consumed, while about one-third sent out part or all of their laundry and nearly 9 out of every 10 women bought canned foods.

A few women felt that it was a hardship to have to carry on income-producing work in addition to that of the home, and a few others reported that their husbands did not like to have them do so. In most cases, however, both the worker and the family seemed not only willing but anxious that her work should continue.

Planned spending for better family living.—Family account books kept year after year are exceedingly valuable, not only to the individual families keeping them, but also to all who are interested in the changes in spending habits which follow changes in income. As noted in previous reports, account keeping has become a habit among Illinois farm and village families largely as a result of the continued efforts of the experiment station workers to help the individual families view their own situation and evaluate their spending and saving habits in comparison with the general trends as shown by careful analysis of each year's records.

For the year 1935–36, 278 home-account records sufficiently complete to summarize were received at the station. Of these, 216 were from farm families and 62 from town families. In comparison with the figures for the 231 farm-family records studied the previous year, there was nearly 16 percent more realized income and 20 percent more cash available for family use. How was this increase spent? It was used for increasing life insurance payments and decreasing indebtedness, for buying more fresh fruits and certain luxury food items, for repairs and upkeep of the house, for the replacement of furnishings and the purchase of new furniture and equipment, for new clothing, particularly for the housewife who had to practice rigid self-denial during the depression, for new or later model cars, and finally for increase in health and recreation expenditures. "It would appear that choices in spending are being weighed in terms of satisfactions in living for the family." The greatest value of these Illinois home-account records, kept year after year, is the opportunity they afford for long-time planning, based upon the adjustments which have been necessary with the inevitable shifts in family income.

Occupations of farm-reared youth.—The complex factors involved in family living undoubtedly play an important part in determining the future of the young people in the family. There are some who go so far as to say that the physical equipment of the home is a significant factor in determining how long the children will remain in the home. In a limited study at the Connecticut (Storrs) Station of the relation of the equipment of rural homes for the promotion of convenience, comfort, and health to the proportion of sons and daughters 16 years of age and older continuing to live at home, the conclusion is drawn that—

if young people, and young women in particular, are to prolong their residence in their paternal homes, the equipment of these homes as to convenience, comfort, and health must measure up well with the better current standards of domestic life in this country.

For most rural homes, however, it is even more important to determine the factors responsible for the type of occupation which the sons and some of the daughters will follow. In farming, as in any other occupation, the son may not always wish to follow in the footsteps of his father. Is it as easy for the son in rural families to select an occupation to his liking as in urban families? In a recently completed investigation by the Mississippi Station of the occupations of

sons and daughters of Mississippi cotton farmers, three-fourths of the more than 1,500 sons and daughters 19 to 34 years of age were farmers, or were dependent at least in part upon the farm for livelihood. An attempt to determine the factors responsible for this situation led to the conclusion that the principal factor was that the majority lived where opportunities for engaging in any kind of work except farming were limited. Many of the group studied were still too young, 19 to 23 years of age, to have become permanently established. Many of the families were tenants with little opportunity afforded the younger people for entering nonfarm work. The limited schooling of most of the young people was another factor preventing them from seeking other occupations.

Looking into the future, the Mississippi investigator pictured the desirable occupational situation for this group of cotton farmers' sons and daughters as—

> a situation in which each of them had the opportunity and training to engage in the occupation best suited to his ability. There are three methods, it is believed, of bringing about such a situation: (1) Public provision of more educational facilities than in the past; (2) greater public supervision of health and control of sanitation; (3) an increase in the general level of incomes. * * *
>
> The vocational situation of rural young folk is a vital family problem, but its solution lies largely in the hands of the State. Upon the family, however, rests some of the responsibility for training and most of the responsibility for exposing their children to situations where they will have more occupational opportunities. There are latent in every community opportunities for the development of abilities and vocations of sons and daughters. It is the responsibility of the family to seek these out, to improve them, or to move them elsewhere if need be.

Family relationships.—In times past much more attention has been paid in experiment station research on home problems to the tangible than the intangible factors affecting family life. However, a growing interest is being shown in personality and family relationships. These factors are given some consideration in the Mississippi study noted above, and even more in two investigations at other stations which are under way. One of these, at the Nebraska Station, is a comparative study of young people from farm, village, and city homes in regard to possible relationships between character and personality adjustment and home and family influences. The other, which was started toward the close of the year at the Virginia Station, deals with the interests, problems, and activities of white rural homemakers in a certain district in the State. These two projects should make a valuable contribution to the quality of living in rural homes.

See also page 179.

Sybil L. Smith.

RURAL ECONOMIC AND SOCIAL CONDITIONS

The State stations continued to make progress, noted in previous reports, in rounding out their programs with a view to the development of more adequate bodies of information, needed as a background for the improvement of rural economic and social conditions. The Nation-wide project in agricultural adjustment, participated in cooperatively for the past 3 years by the 48 State stations and the Federal agencies concerned, has incidentally contributed to the satisfaction of a long-felt want in scientific agriculture. It has demonstrated the desirability of synthesis and generalization based upon

analysis and specialization in agricultural research. By synthesis the findings of specialists in the several fields and subfields of research are integrated into more workable bodies of information of sufficient scope to be helpful in dealing with the broader questions of agriculture and rural life, and their progressive adjustment. This effort at relating the many specific findings of specialized research has also called attention to existing gaps in research programs with the result that many of these gaps are being filled in by further specialized research undertakings. Evidently, synthesis, leading to generalizations based upon specific findings inductively arrived at, is becoming one of the more generally recognized functions of American agricultural research agencies.

By extending their programs to include technical, economic, and social studies, essential to agricultural adjustment, soil conservation, rural resettlement and rehabilitation, and related problems, the stations are making important contributions to rural progress. Cooperation between the State stations and Federal agencies is greatly facilitating the synthetic method of dealing with local, regional, and national problems in a more effective manner than has been possible heretofore.

In the field of agricultural economics, the projects carried on Federal funds were distributed as follows: Out of 385 projects active during the year, 56 were new, while 54 were completed or discontinued. Of the active projects, 46 were in agricultural adjustment, 92 in farm management, 85 in marketing, 32 in taxation, 21 in finance, 7 in tenancy, 41 in land economics, 25 in prices, 15 in rural business analysis, 15 in cooperation, and 6 in miscellaneous studies.

In rural sociology, studies conducted on Federal funds increased from 55 to 64 active projects during the year, a rather significant increase in number for this relatively new field of research. Of the 64 active projects, 15 were in studies of rural population, 8 in standards of living, 3 in social psychology, 1 in rural health, 4 in rural welfare, and 33 in rural social groups. Of the last mentioned, the study of the rural family, the rural community, and rural organizations was emphasized. In addition, many studies throwing light on problems of rural rehabilitation, tenancy, and related problems were conducted on State or local funds in cooperation with Federal agencies concerned. Everything considered, the depression of the 1930's evidently brought forth an interest in the study of rural-life problems comparable in some respects to that created in farm management and agricultural economics by the depression of the nineties and succeeding depressions. Rural sociology, therefore, is finding its place in both State and Federal research programs.

ECONOMIC CONDITIONS

LAND USE

The Nation-wide interest during the past few years in crop adjustments, soil conservation, rural resettlement, and rehabilitation and other land problems, as would be expected, resulted in the State agricultural experiment stations placing much emphasis on the extending and rounding out of their past studies in types of farming and range management, use of marginal and submarginal lands, etc., and undertaking other studies related to more efficient conservation

and use of land. Cooperation between the Federal agencies and the State stations, among the several subject-matter departments of the individual stations, among the stations of different States in the same agricultural region, and with State land-planning boards and counties on coordinated programs and investigations has continued to increase.

A few of the findings in the many studies reported on by the stations are cited as illustrations of the type of work in progress and of the recommendations resulting from such studies.

Land use in the Corn Belt.—The Iowa Station, in a study of livestock farming in that State as related to hay and pasture, made four findings it considers fundamental to the development of a sound long-time agricultural program for the State and the Corn Belt:

(1) Moderately increased acreages of soil-conserving crops may be expected to have little effect on total feed production in the State, except over a long period of time, tending to maintain it at a higher level than would be possible if present depletion is allowed to continue, especially on the highly erodible soils. (2) Elasticity in the use of Iowa feeds by the different classes of livestock is sufficiently great to suggest that a 10-percent reduction in grain accompanied by a corresponding increase in hay and pasture will not, in itself, have any significant effect on the type of livestock and livestock products produced in Iowa. (3) Increased acreages of hay and pasture on many present grain-selling farms may be expected to be accompanied by increased livestock production on these farms. The motive for increased livestock production set up by the production of additional nonsalable roughages may be expected to result in more livestock being kept—both hogs and cattle—resulting in significantly less grain being shipped from these farms. (4) The feeding of a higher proportion of grain on the farms where it is raised will make the problem of soil conservation and the maintenance of an adequate volume of business even more acute on the present small highly erodible farms, where additional grain is now purchased, both within and outside the State.

Crop adjustments for Illinois.—Based on a study made in cooperation with the Department of Agriculture (B. A. E.) and other Federal agencies, the Illinois Station suggests that desirable adjustments in land use in that State would include the following changes from the land uses in 1929: The devoting of 2.2 percent of the land in farms in 1929 to timber and recreational purposes; the putting of small bodies of badly eroded land, averaging about one-half acre per farm, into farm wood lots; the changing of about 2.5 percent of the land in farms from harvested crops to pasture use; the increasing of the acreage in hay about 10 percent; the decreasing of the acreage in corn about 11.5 percent, that in wheat about 2.2 percent, and that in oats and mixed grains 8 percent; and the increasing of the acreage of soybeans 143 percent, an increase less than that which had taken place by 1934 and 1935. It is also suggested that all the land used in a crop rotation should have the benefit of a soil-building legume crop at least 1 year out of 5. With these changes it is estimated that the number of cows milked could be increased about 7.4 percent and the total live weight of the cattle and calves produced for sale annually about 8.8 percent. The live weight of sheep and lambs would probably increase about 43.6 percent and the total hog production could be decreased 14.7 percent.

Land use in Utah.—The Utah Station, in a 3-year study of farms in the vicinity of Delta, Millard County, recommended that in the reorganization of the agriculture in that area the capacity of land to produce should be the basis of reorganization, all large areas not normally producing sufficiently to pay costs of production should be

taken from cultivation, irrigation waters should be transferred from the less to the more productive soils, larger farm units should be established, and livestock production should be made the major enterprise.

Land use in Louisiana.—The Louisiana Station, in a study of the use of land in 13 parishes in the heart of the sugarcane area of that State, found that over 259,000 acres of cultivable land was idle in 1934. Sugarcane was the previous crop on 49 percent of the idle land and rice on 15 percent. The operators indicated a desire to nearly double the acreage of sugarcane in 1934. Such an increase, it is estimated, would require about 13,500 more regular workers, an increase of 125 percent in the extra workers required for hoeing, and 91 percent in the number required for harvesting. There would also be a considerable increase in the requirements for capital goods, mostly local products.

Land use in New Hampshire.—The New Hampshire Station, in a study of the back highland area in southern Grafton County, found that of 252 farm operators, 118 sold less than $50 worth of agricultural products in 1934 and only 19 sold over $1,000 worth. Most of the families were dependent upon outside work for their living, and little productive employment was available. The net cash income of approximately half of the families was less than $200. Nearly half the farmers had moved on to the farms within 10 years. The station states:

> There seems a possibility for the rebuilding of a permanent, economically, and socially healthy community through four interrelated programs: (1) Realignment of people to the resources and institutions by relocation of isolated homes to the vicinity of main roads; (2) reorganization of local government units and readjustment of public services; (3) development of resources, mostly timber; (4) relating the local resources to local people through employment.

The station suggests that a forest conservation program would be preferable to public ownership in the area, as people could be more easily and satisfactorily related to the resources, the investment of public funds would be smaller, and the local people would retain control over the land.

Maintenance of soil productivity.—The Ohio Station developed a method for calculating the net annual effect, or productivity balance, for a given rotation and for all crops grown on a given farm. Using this factor, a study in 10 counties showed that the productivity of the soil on approximately 20 percent of the farms was being maintained by the practices followed in 1936. The labor income on these farms was also higher than on other groups of farms. In Wyandot County, for example, on 80 farms studied, the average labor incomes per farm were $1,604 on 12 farms maintaining soil productivity, $1,400 on 24 farms in the group with a −0.23 annual productivity balance, and $875 on the 17 farms in the −0.53 productivity balance group. The farms maintaining soil productivity, as compared with the −0.53 productivity balance group, had about one-fifth less of the rotated area in corn and one-fourth more in hay and rotation pasture and twice as much livestock.

See also page 14.

FARM TENANCY

The problems of farm tenancy—its extent, its economic and social effects, leases, means of making it possible for tenants to become

owners, methods of improving social and economic conditions of tenants and farm laborers, etc.—have received much consideration by the stations during the past year. As in the land-use studies, much of the work has been done in cooperation and coordination with Federal agencies, especially the Bureau of Agricultural Economics of the Department of Agriculture.

Farm tenancy.—The Iowa Station, in studies of farm tenure and tenancy, found that half of the farms of the State are now tenant-operated, the percentages in different counties varying from 32 to 67. The 1935 Federal census disclosed that over one-third of all tenants had been on the same farm for 1 year or less. Twenty-eight county agricultural conservation committees, cooperating with the station, estimated that on the average tenants stay on one farm about 4 years. The station concludes the facts that on an average tenant farms are more heavily cropped and subject to more erosion, soil depletion, and deterioration of buildings and other improvements are not necessarily due to tenants, as a group, being inferior farmers but because the system of tenancy, the leasing practices, and the commonly prevailing landlord-tenant relationships are such as to discourage the adoption of good farming and soil-conservation practices. The lack of security in tenure of tenants results not only in great financial loss to the tenants, but in loss to landlords from the deterioration of land and improvements and to the community from stagnation in its economic, social, and cultural developments.

The station points out six important causes of the serious lack of security of tenants: (1) Lack of knowledge on the part of some landlords of farming in general and what the individual farm is worth, which leads such landlords to make unreasonable demands on tenants, as to the amount of rent, the time of payment, the making of major repairs without compensation, and being content with inadequate improvements and a low standard of living; (2) financial distress of landlords, making it impossible for them to finance tenants in periods of depression and crop failures, to keep up improvements, and to make repairs and necessary additions; (3) desire of landlords to be in a position to sell whenever an attractive offer is presented; (4) the keen competition among tenants for farms, resulting in rents being bid up, sometimes knowingly, to a point where they cannot be lived up to; (5) the moving of some tenants to better farms, better communities, and better landlords; (6) the elimination of unsatisfactory tenants. Of these causes, only the last two are socially beneficial. Another cause affecting the increase of tenancy, the opportunities of tenants to purchase farms, and the need for careful appraisals for sales and loans is brought out in another study of the same station of corporate-owned lands, which shows that the area owned by insurance companies, mortgage companies, Federal loaning agencies, etc., increased from practically nothing in 1920 to 2,688,000 acres, 7.9 percent of the farm lands of the State, in September 1933 and to 3,813,000 acres, 11.2 percent of the total, in January 1937.

The Idaho Station, in a study of the Minidoka project of the United States Reclamation Service, found that a large part of the tenant farming is detrimental to soil conservation and a hindrance to the realization of the full productive capacity of the project. Among the needs brought out are education to acquaint tenants and

landlords with more workable and equitable lease contracts and along lines of appraisal of land for sale, assessment, and loans, and the encouragement of the purchase of lands by worthy tenants.

The Arkansas Station, in a study of plantation operations of landlords and tenants, found that the size of tenant farms has remained practically stationary, with a tendency to decline in size since 1920 and that because of low wage scales, use of better equipment, tools, and farming methods, and the flexibility in the use of productive agencies, the wage crop method, in most situations, gives better financial results to landlords than does the tenant system. The station concludes that if the tenant system is to continue, both landlords and tenants will be benefited by utilizing better tools, equipment, and machines and that this will be made easier by enlarging tenant farms to facilitate the use of improved farm methods and a fuller use of the time of tenants and by making provision for wage labor, if needed, to assist tenant families during periods of hoeing and picking cotton.

The Virginia Station found that approximately one-third or more of the farms in one-third of the counties were operated by tenants in 1935. In seven counties, from 53 to over 67 percent were so operated. The station states that the question of most concern is not one of tenancy alone, but of the marginal population associated with it. This fact is borne out by a study of nearly 6,000 white families in 16 communities, which showed that 57.6 percent were paying no real-estate and personal taxes, or less than $2.50. These families furnished more than half of the children to be schooled and made into future citizens. Of 1,282 children from marginal families in one county, 63.6 percent had dropped out of school under the fifth grade; 24.7 percent between the fifth and seventh grades; and less than 1 percent had finished high school. Nearly one-half dropped out under 12 years of age and nearly one-third at from 13 to 14 years. It is indicated that among the things needed to improve the situation are a liberal policy of credit aid from public agencies for the purchase of land; a general increase of agricultural income to make it possible for tenants and laborers to have a decent standard of living; a better system of tenant contracts to reward tenants for improvements and to lessen exploitation of the land; educational policies that will more effectively meet the needs of the marginal groups; and a more intelligent public consciousness of the social consequences of the present trends.

Farm leases.—Both the Iowa and Illinois Stations have suggested types of leases, lease provisions, etc., with a view to bringing about better landlord-tenant relations, greater security of tenure for tenants, and more effective conservation of lands and improvements. The Illinois Station outlined a plan for adjusting cash rental to changing price levels.

Acquiring ownership by payments in kind.—To enable tenants to purchase land, the Missouri Station proposes that a plan of land sale based on payments in kind be undertaken. The proposal is to develop a system of amortizing the full value of the farm based on a level of productivity determined at the time of sale through annual payments of a definite number of units of a generally recognized farm product, or products, of a definite grade. It is pointed out that under such a plan the seller would assume the risk of price

changes and the buyer that of seasonal variations in yield, in addition to the responsibility for taxes and the upkeep of the property. Improvements in productivity by the buyer would be encouraged since they would accrue to his benefit.

Profitableness of tenant farms.—The Illinois Station, from a study of records covering a period of 10 years from the better farms in an area typical of the best farming section of the central part of the State, concludes that there is no reason why tenant lands cannot be as profitably operated as owner-operated farms if the tenant farms are operated under proper types of leases and arrangements. Analysis of the records of an average of more than 200 farms a year showed the earnings on total farm investment to be 3 percent for owner-operated farms, 3.7 percent for farms partly owned by operators, 3.2 percent for those operated by tenants related to the landlord, and 3.8 percent for those operated by unrelated tenants. More efficient use of labor, power, and equipment on the partly owned and unrelated tenant farms was one of the chief factors accounting for the higher earnings on such farms. The facts that the owners were older and consequently not exerting themselves so greatly in some cases and that the acreages in owner and tenant related farms were smaller accounted in part for the lower earnings of these groups. In general, the station found that tenant farms are not more profitable than owner-operated farms when all farms in an area are considered and that the disturbing factor in tenancy is the many poorly supervised farms, which, although perhaps showing good current returns, are following soil-depleting systems of farming.

TAXATION AND USE OF TAX FUNDS

The recent depression years have emphasized the heavy tax burdens on farm lands and the need for fuller reliable information as to valuations, assessments, delinquency, expenditures for different purposes, and means of correcting inequalities, lessening delinquencies, and curtailing expenditures without damage to schools and other essential services such as roads and county government. A considerable number of the stations have been active in such investigations, much of the work being done in cooperation with the Department (B. A. E.).

Taxation and public expenditures.—It was found by the Oregon Station, in a study of public expenditures for 1910 to 1934, as measured by tax levies imposed upon general property, that there was concrete evidence of the impossibility of rapid retrenchment of public expenditures and tax levies in periods of economic depression because of the fixed nature of many of the expenditures, existing long-time commitments, salaries, fees, and levies being frequently fixed by statute or the organic law of the State, and the reluctance of people to surrender customary public services. It was also found that decreasing expenditures may not effect a decrease in tax levies due to the shrinkage in taxable values, and more particularly to the increase in tax delinquency. The study further showed that the peak of general property taxes in Oregon, in terms of actual purchasing power, lagged 2 years in the case of rural taxes and 4 years in the case of urban taxes behind the peaks as shown by the tax rolls.

Tax assessments.—Studies by the Kansas Station, in cooperation with the Department of Agriculture (B. A. E.) and the Civil Works Administration, and of the South Carolina Station, in cooperation with the United States Bureau of the Census, brought out the inequalities in tax assessments in general, and particularly of properties of low sales value as compared with those of high value. The average ratios of assessed to sales value found by the Kansas Station for the properties studied increased from 65.9 percent for those with a sales value of $15,000 and over to 166.2 percent for those with a price of less than $5,000. In South Carolina the ratios increased from 74 percent for properties valued at $15,000 to $20,000, to 150 percent for those valued under $2,500. The ratio in Kansas was 100.5 percent for properties selling at $3,000 to $5,000 and in South Carolina 98 percent for those valued at $2,500 to $5,000.

Another study by the South Carolina Station showed that in a single county the ratios of assessed to sales price on farm real estate had varied in a single year from less than 10 percent to over 100 percent and from an average of 17 percent to 74 percent over a period of 20 years. The Kansas Station found that during the recent period of economic depression, assessed values of lands were more nearly approaching sales value, being 94 percent in 1933 as compared with approximately 69 percent from 1923 to 1930.

The Montana Station found that under the present assessment basis the assessed values are 46 and 58 percent, respectively, of the productivity values for first- and second-grade farm lands as compared with 325 percent and 408 percent for third- and fourth-grade farm lands and from 236 to 780 percent for the five grades of grazing lands.

Rural tax delinquency.—A study by the Pennsylvania Station, in cooperation with the Department of Agriculture (B. A. E.) and the Civil Works Administration of rural tax delinquency, 1928–32, showed that in the 50 counties studied, approximately 20 percent of the privately owned rural real estate was delinquent in May 1933. The delinquency was six and two-thirds times as great as in May 1929 and in 1932 was approximately $20 per farm for all farms assessed. While the least delinquency, both in proportion to value of land and to number of farms, was in the counties having the most intensive agriculture, the percentage of increase was greater in such counties.

The Kansas Station, in a study covering the same period as the Pennsylvania study and in cooperation with the same organizations, showed that the amount of taxes delinquent increased nearly 131 percent during the period, the percentage of delinquency for the individual years increasing from 6.5 percent in 1928 to 21.7 percent in 1932, notwithstanding that the total taxes levied had decreased approximately 30 percent. In 1928, 5,000,000 acres, or nearly one-tenth of the farm lands of the State, were involved in tax delinquency and in 1932 over 16,000,000 acres, or nearly one-third of the land.

The accumulated unpaid delinquency in 18 counties studied by the South Carolina Station, in cooperation with the Department (B. A. E.) and the Federal Emergency Relief Administration, increased from 36 cents per acre in 1928 to 92 cents in 1932.

From a study of tax delinquency of forest lands, the Arkansas Station concludes that the following developments are needed in that State to effect permanent improvements in the forest land tax delinquent situation in the State: Additional surveys to provide accu-

rate data on the natural resources, public finance, ownership and intent in ownership of all rural lands, the social and economic status of the population, the industrial development of the State, existing and needed legislation, and similar factors; further revision of the laws and practices in respect to assessment and collection of taxes; and for forest lands, further demonstration and extension work in forestry, adequately financed and with trained personnel, to assist timber owners in managing their timber lands so that they remain as permanent assets.

In the revision of the laws and practices the station recommends that assessments be at full actual value as determined by competent assessors, after careful analysis of elements affecting value; that interest 1.5 percent above the prevailing commercial rate be charged on delinquent taxes; that a nominal discount be allowed on prompt full payment of current taxes; that rural acreage property that has been duly and legally forfeited and certified to State title for nonpayment of taxes be promptly classified by the State Planning Board as to its suitability and adaptability for private or public development and use, and that lands classified as unsuitable for private use be devoted only to public use; and that the sale price on certified lands classified as suitable for private use during the 5-year period following the final certification to State title be at actual value but not less than (1) the assessed valuation at time of forfeiture or (2) the total taxes, penalty, interest, and costs due and accrued against it, whichever shall be greater. In case of lands remaining unsold or unredeemed for 5 years, a reexamination and classification should be made, and, if again classified as suitable for private use, the land should be offered at public auction to the highest bidder.

Cost of schools and county government.—It was brought out in a study by the Montana Station on the organization and costs of elementary and secondary schools that 46 percent of the real-estate taxes paid by farmers of that State are used to finance such schools and an additional 5 to 10 percent is used indirectly for school supervision and administration. Among the weaknesses found in the present financial and administrative organization were too many administrative units, too many small, inadequately taxing units, too many schools with extremely low pupil-teacher ratios, unwieldy and inefficient accounting procedure due to extreme decentralization of administration, and too great reliance on local taxes, resulting in unstable financial support and inequalities in tax burdens. Appreciable reductions of the number of administrative units and substantial support from State and Federal sources to supplement local, district, and county taxes are considered essentials of any reorganization plan.

The Arkansas Station, in a study of cost of county government, found the average per capita cost in the years 1931 and 1932 to be $4.14, of which $1.27 was for administrative costs, a like amount for general county purposes, including bonds, and $1.60 for roads. The station states:

> If worthwhile county governmental reform is ever to be realized, it will be necessary to amend the constitution. The least that a constitutional amendment, for this purpose, should provide, at the option of the county, are the following: (1) Consolidation of county offices and rearrangement of the duties between officers, (2) management of the fiscal and personnel affairs of the county, (3) substitution of appointive for certain elective officers, particularly

the tax assessor, and (4) an elective board of managers, not to exceed 15 members per county, to take the place of the present quorum court, to have official charge of all county business, including administrative offices, special services, and the county road system.

It is suggested that the privilege of county consolidation or changing county boundaries might also be provided.

In a somewhat similar study by the Missouri Station of the costs of government in 11 counties during the period 1930–34, it was found that the very unequal distribution of the costs was traceable directly to fundamental faults in settlement and that county consolidations, consolidation of offices within the counties, and possible improvements of efficiency in operation would not overcome the inequalities in underlying taxable resources. Consolidation of counties, it appears, would affect expenditures for roads and schools, which constitute nearly 73 percent of all expenditures, very little and other expenditures only moderately. Attention is called to the fact that while consolidations might effect government savings of several thousand dollars for each consolidated unit, such savings would be offset in part by the additional cost to citizens in transacting business with the government, due to the greater additional distances to the county seat. To reduce the inequalities in the counties, the station presents three possible procedures as worthy of consideration—the turning over to the State of a larger part of the cost of local government; the inauguration of a program of resettlement with the express purpose of reducing population and increasing the ratio of taxable resources to population; and efforts to increase taxable wealth by increasing the productiveness of the underlying natural resources.

Analysis of the receipts and expenditures for county and school purposes in 1933 in 38 counties of the State by the Texas Station showed an average per capita cost of $18.83, of which $8.16 was for education. The costs were $28.18 and $12.36, respectively, in counties of 5,000 or less in population and $15.99 and $7.58, respectively, in counties with over 35,000 population. Reorganization of the school system as rapidly as possible along the plan outlined by the State Board of Education and the use of State funds to equalize educational advantages are pointed out as means by which the major existing inequalities in educational opportunities may be accomplished without increases in cost. Consolidation of counties, adoption of either a county manager or county executive plan of organization, cooperation of counties in furnishing services, and State interest and responsibility in improving budgeting and accounting practices, assessment, and collection of taxes, and creation and administration of indebtedness are methods recommended for reducing costs and promoting efficiency in county government.

The station suggested that in consolidation, a county should have a minimum population of 20,000 and a minimum assessed valuation of $10,000,000 to $12,000,000. It is estimated that on such a basis the counties studied that had less than 5,000 population would save $2.91 per capita, an amount equal to 21 percent of the total cost of county government, 25 percent of the current or operating cost, and 65 percent of the cost affected by the consolidation. The analyses of the expenditures of the counties with 20,000 to 25,000 population indicated that the adoption of the county manager or county executive plan of organization, in addition to providing additional and improved

services, would result in a saving of $10,000 to $15,000 in salaries, and in many cases probably in an equal saving in the purchasing of supplies, the operation of roads and bridges, and other services.

MARKETING

Wholesale fruit and vegetable markets.—Studies by the Maryland Station of the Baltimore wholesale markets for fruits and vegetables and of the Pennsylvania Station, in cooperation with the New Jersey Station and the Department of Agriculture (B. A. E.), of the Philadelphia markets showed that one of the primary causes of much of the inefficiency and high cost of marketing in both cities is due to the present market set-ups, which in both cities are on the arbitrary basis of whether the produce arrives by rail, boat, or motor, rather than on the basis of type of sale (wholesale or jobbing). This frequently necessitates the buyers visiting not one but several of the markets to obtain a full line of produce, much cross hauling, rehandling, loss of time, high sales cost, and waste. Increased use of motor trucks has resulted in both cities having excess facilities for handling rail shipments and inadequate facilities for handling the increasing volume of truck shipments. The Pennsylvania Station reached the conclusion that—

> The development of direct purchases and transportation by motor truck from producing areas are a challenge to the fruit and vegetable interests of the Philadelphia market. This has been a development of the past decade. The rapidity of this movement will depend to a great extent upon comparative costs. So long as buyers in smaller cities can purchase and transport by truck direct from producing areas more cheaply and more efficiently than they can purchase in the Philadelphia market, the present tendency to avoid the Philadelphia market is likely to increase.

A study by the Connecticut (Storrs) Station of the marketing of fruits and vegetables in Bridgeport, Waterbury, and Hartford showed that small retail stores tended to be served by direct store delivery on the part of jobbers, truckers, and farmers and that the patronage of farmers' markets by such stores is slight. The station concludes:

> The volume and variety of vegetables consumed in our cities and the mobility and speed of delivery made possible by the motor truck point to the need of a large centralized market with a wide variety of fruits and vegetables to attract large buyers. Such a market would promote increased consumption of native vegetables within the State because of improved facilities for distribution and would also make it easier to take the surplus out of the State. At present large buyers have no market in Connecticut that fully meets their needs as to the time of day the market is held, room to move around in the market, standardized packaging, and volume of produce offered for sale.

Other studies of city markets included that of the Louisville wholesale fruit and vegetable market by the Kentucky Station; the markets for agricultural products in the Middle Rio Grande Conservancy District by the New Mexico Station; the Peoria market for fresh fruits and vegetables by the Illinois Station; the Twin City milk market by the Minnesota Station; the organization and operation of 20 city markets in Indiana, and grades, price trends, and sales on the Indianapolis producers' market by the Indiana Station; the Charleston market for fruits and vegetables by the West Virginia Station; and the markets for frozen-packed fruits by the Tennessee Station.

Minnesota outlets for fruits.—The Minnesota Station, in a study of market outlets for fruits of the State, found that almost the entire strawberry and raspberry crops were sold for fresh fruit for table use and home canning and that less than 2 percent of the expenditures of commercial factories in the State for these fruits was for Minnesota-grown berries. The present limited use of Minnesota berries for commercial preserving, coupled with the high prevailing prices, indicated the need of a hardy preserving type of red raspberry similar to Cuthbert in quality. A raspberry of this character should be of immediate commercial value to the growers. The study indicated also the possibility of developing an outlet for strawberries in the ice cream industry if the fruit were preserved by the frozen-pack method and packed in suitable sized containers. The 14 most promising Minnesota varieties of apples were found to be, as a rule, satisfactory for commercial pie manufacture, and one variety (Minn. No. 790) was found entirely satisfactory for the baked-apple trade.

Motor transportation of fruits and vegetables.—A study of marketing fruits and vegetables by motortruck in western Maryland, made by the Maryland Station, showed that the marketing cost averaged $7.69 per ton, or 27.8 percent of the gross value of the products. Commission fees constituted 16.1 percent of the total costs; transportation, 27.2; containers, 38.1; other selling costs, 15.4; and storage, 3.2 percent. The total marketing costs for individual commodities varied from 20 to 37.4 percent of the gross value.

Milk transportation.—The Illinois Station, in a study of milk-transportation problems in the St. Louis milkshed in 1933 and 1934, found that the farmers paid nearly $1,000,000, or approximately 17 percent, of the wholesale value of the milk for transporting it from the farm to receiving plants. The difficulties of the transportation problem were increased by the low production per cow and sparse cow population in the milkshed. The station estimates that (1) at least 20 percent of the trucks in use could be eliminated if seasonal fluctuations in milk production could be reduced to those of the Philadelphia milkshed and the volume on each remaining truck route increased to a practical seasonal capacity; (2) if the one-fifth of the milk hauled to the city and manufactured into butter and other dairy products had been marketed through the country plants, 16.3 cents per 100 pounds, or a total of $74,000, could have been saved by the farmers; (3) if hauling routes were rearranged on an economic basis to reduce distances and increase volume per load, a saving of approximately $250,000, or $24 per farmer, yearly could be accomplished; and (4) the unnecessary delays in unloading milk at receiving plants resulted in an annual loss of more than 70,000 man and truck hours.

The New York (Cornell) Station, in a study of the transportation of milk and cream to the New York City market, found that rail shipments of milk decreased approximately 50 percent from 1930 to 1935, while receipts by truck increased nearly 600 percent, and constituted over 84 percent of the receipts by rail in 1935. Receipts of cream and plain condensed milk by truck in 1935 were approximately 35 percent of those by rail. The average cost of operating a truck with an average load of 1,722 gallons of milk was 15.5 cents per mile, of which nearly one-third was driver's wages, one-fifth depreciation and interest, and 14 percent for gasoline.

Western cream for eastern markets.—The results of a cooperative study by the Farm Credit Administration, the Department of Agriculture (B. A. E.), and the New York (Cornell) Station are thus summarized in a recent report:

> Shipments of western cream to eastern markets had reached considerable proportions by 1925. The volume of western cream increased rapidly until 1933, when larger surpluses in the eastern milksheds, more strict sanitary requirements, and low cream prices compelled many of the western plants to reduce or discontinue shipments. During the last year or two, however, higher cream prices in the East have induced many of the western plants and farms to make the improvements which are required by health officials of the eastern cities or States. Formerly most of the western cream was used in the manufacture of ice cream or cream cheese. As higher sanitary requirements are put into effect, and the quality of western cream is improved, supplies from that source will compete more directly with eastern supplies for the bottled cream trade.

Creamery expenses and margins.—In a study of the reports and records for 1933 to 69 cooperative creameries, the Iowa Station found that the operating expenses per pound of butterfat handled averaged 3.8 cents for the creameries handling less than 250,000 pounds, 3.24 for those with 250,000 to 450,000, 2.67 for those with 450,000 to 650,000, and 2.37 cents for those handling over 650,000 pounds. The margins retained by the creameries averaged 3.71, 3.31, 2.89, and 2.57 cents, respectively, for the four groups. In 19 creameries, for which records were available back to 1929, the average operating expenses per pound of butterfat decreased from 3.72 cents in 1929 to 2.66 in 1933 and then increased to 2.81 in 1934. The margins retained by the creameries decreased from 3.84 to 2.84 cents in 1933 and then increased to 2.93 in 1934.

Farmers' elevators.—The Illinois Station found that the success of farmers' elevator companies depends largely on the handling of approximately 300,000 bushels, at least, of grain annually; merchandising of side lines sufficient to make up for a volume of grain less than 300,000 bushels; grain buying and sale practices that result in adequate margins; avoidance of speculative losses on falling markets; adequate margins, rapid turn-over, and strict credit and collection policies on side-line business; good accounts, proper audits, and periodic reports to directors; and economical operation without sacrifice of efficiency. The study showed the margins earned on grain to be the most important factor affecting the earnings of companies handling an adequate volume of grain. Margins on merchandise averaged about three times those on grain, this higher margin approximately measuring the difference of the cost of handling grain and merchandise.

The Kansas Station, in a similar study, found that an adequate business in cooperative elevator associations was associated with a membership of 150 or more, 100,000 bushels of grain handled, a capacity turn-over of 10 for the average elevator, and at least 85 percent of the members patronizing the elevator. In general the margins maintained were 4 cents per bushel of grain handled. Net profits tended to increase with the increase in the amount of side-line business until side-line sales exceeded 20 percent of the total business. The study also brought out the need for a rigorous credit policy where side lines are handled.

COSTS OF PRODUCTION

Milk.—Studies by several stations brought out the importance of a number of factors upon cost of milk production. The West Virginia Station, in a study of the Huntington and Charleston areas, found the cost per 100 pounds of 4-percent milk, f. o. b. the farm, to be $2.20 and $2.26, respectively, if no credit was allowed for manure, calves, and appreciation. Feed costs were 52 and 58 percent of the total cost. A comparison of the low- and high-cost herds showed the high costs to be due to less-than-average production per cow, too heavy feeding of grain too high in protein in relation to roughage fed, and high cost for use of buildings and other items beside feed and labor.

The Maine Station found the average net costs per 100 pounds of 4-percent milk to be $2.55 in the Portland area and $2.20 in the three areas—Portland, Bangor, and Waterville—studied, of which feed comprised 58 percent and man labor 22 percent. The cost varied from $2.69 per 100 pounds in herds producing less than an average of 5,000 pounds of milk per cow per year to $1.68 in herds producing an average of over 9,000 pounds per cow. In herds of 20 cows or more the cost was $2.28 as compared with $2.06 in herds of less than 15 cows. The larger herds on an average required 163 hours of man labor per year per cow, the smaller herds 209 hours.

A study of the Vermont Station in the Champlain Valley showed that as the amount of grain fed per cow per day increased from about 2 pounds to approximately 6 pounds, the average daily milk production rose from 10 to 15 pounds and the net cost of production decreased. Herds fed over 7 pounds of grain per day per cow averaged but little more than 15 pounds of milk per cow and the net cost was higher.

For herds studied by the Michigan Station in 1935–36, the average costs were $1.86 per 100 pounds of milk and 42.9 cents per pound of butterfat. The total cost of butterfat decreased from 41 to 33 cents per pound and the labor returns per hour increased from 33 to 54 cents as production of butterfat per cow increased from 236 to 422 pounds. Management returns were six times as great in herds of 26 cows as in herds of 6 cows.

Apples.—The cost of producing and marketing apples in 80 Berrien County orchards in 1935 was found by the Michigan Station to average $36.13 per acre for production costs, $37.37 for harvesting and marketing, and $31.13 for overhead costs. The average profit was $1.56 per acre, or 0.8 cent per bushel. The 15 most profitable orchards showed a profit of $43.32 per acre and the 15 least profitable ones a loss of $36.83. A yield of approximately 200 bushels per acre was necessary to pay costs of production if no credit was allowed for appreciation of the trees. Orchards with 35 to 40 trees per acre gave the highest returns, while costs per bushel were lowest in orchards of 10 to 20 acres.

Fat lambs.—A study of costs and returns from lamb feeding from 1930–35 by the Michigan Station showed the average net returns per dollar's worth of feed fed averaged $1.40 for the period, ranging from −5 cents in 1934–35 to a return of $1.79 in 1933–34. The total cost

of fat lambs averaged $6.51 each, of which 63 percent was cost of feeder lambs and 31 percent feed. The average cost of fattening a lamb was $2.44, of which feed comprised 82 percent; use of barns and equipment, 6; labor, 5; and other costs, 7 percent. Feeding ability of the farmer, margin between purchase and sale price of lambs, daily gain, and death loss were the chief factors affecting the costs and returns.

See also page 121.

Eggs.—In a study of commercial egg production by the Delaware Station, it was found that an increase of 100 layers per flock reduced the cost of egg production 1 cent per dozen. An increase of 10 eggs per layer per year reduced the cost 2.2 cents per dozen. February-hatched pullets as compared with May-hatched pullets laid 41.4 more eggs during the laying season, the value of eggs per bird being $1.86 more and the cost of production no greater. A ratio of approximately 75 pullets and 25 hens was found to be nearer in keeping with good management than the old accepted ratio of 50:50. The station summarizes its findings as follows:

Laying flocks averaging at least 900 birds, pullets hatched in February or not later than March, a ratio of hens to pullets of approximately 25:75, the limited use of artificial lights, the rearing of pullets on limited feeding of a low mash ration when on range, and a conservative culling policy appears to be the most advantageous economic program for Delaware commercial poultrymen.

See also page 122.

PRICES

Prices of agricultural products.—The New York (Cornell) Station, from a study of prices of farm products in the State during the period 1841–1935, concluded:

The major movements of New York farm prices have usually corresponded with the changes in wholesale prices in the United States. Since 1841 changes in New York farm prices have paralleled closely the movements of wholesale prices of farm products in the United States. In general, farm prices in New York have followed trends similar to those of farm prices in Maryland and Virginia. New York farm prices have risen relatively to wholesale prices of all commodities in the United States. During the past 95 years the exchange ratio of farm products in New York to all commodities at wholesale in the United States has been above 100 for 11 years. Five of these years were from 1926 to 1930. Grains, in terms of other commodities, have definitely declined since 1855. The purchasing power of fruits and vegetables has fluctuated over wide limits. The trend has been constantly upward during the period covered by this study. Fruits and vegetables have been relatively high in price since the Civil War period. The purchasing power of hay rose until the middle of the nineties and since then it has declined. Livestock and its products increased in value in terms of other commodities until the outbreak of the World War and declined following that time. The trend in the purchasing power of the dairy group has been upward throughout the entire period studied but at a somewhat less rapid rate since the middle of the nineties. It was not until after 1910 that the poultry group reached its pre-war level. In terms of other commodities, the poultry group rose during the entire period included in this study. There appears to be a cycle in the purchasing power of chickens and eggs, averaging about 17 years in length, accompanied by a secondary cycle a little more than 8 years in duration.

Milk prices, San Diego, Calif.—The California Station, in a study of the price factors in the San Diego milk market, arrived at the conclusion that the base price to producers should be 6 to 8 cents higher than that of 69 cents per pound of milk fat set for the Los Angeles market in September 1936. The station states that a price in San Diego of 75 to 77 cents per pound of milk fat—

would be 70 percent and 72 percent, respectively, of the 1929 level of prices. Farm wages are approximately 72 percent of the 1929 level so that a price of 77 cents per pound of milk fat would have about the same purchasing power in terms of wages as in 1929. Wholesale prices in Los Angeles of a composite feed ration in August 1936 averaged about $18.78 a ton or 0.94 cent a pound. The buying power of market milk at 75 cents to 77 cents a pound milk fat would thus vary from 80 pounds to 82 pounds. This is somewhat higher than the 1929 level of 78.7 pounds. It must be remembered, however, that in 1929 a much larger percent of all milk produced in San Diego County was sold at the base price than is true at the present time. The decline in the average prices received by producers (for all milk produced) is undoubtedly greater than the decline in base prices.

Prices of canned fruits.—In an analysis of the annual average f. o. b. prices of canned clingstone peaches, 1924–25 to 1936–37, the California Station found that the price per case changed 16 cents in the opposite direction, with a change of 1,000,000 cases in the total shipments of California canned peaches, and 45 cents and 20 cents, respectively, in the same direction, with changes of 10 points in the index of urban consumers' income and 10 points in the adjusted index of prices of competing canned fruits. Similar studies were made of the f. o. b. prices of Pacific coast canned Bartlett pears and California canned apricots.

LABOR REQUIREMENTS

Seasonal labor requirements.—Summarizing the results of 59 county surveys, the California Station concludes that the annual need for seasonal labor for these counties is nearly 22,500,000 man-days with the maximum or "peak" need occurring in August, September, and October when the monthly demand averages 2,900,000 man-days. The station says:

> Based on the data presented in the summary report one might conclude that California agriculture offers year-round employment for 48,000 workers, 11 months for 2,000 more, 10 months for another 6,000, etc. But the fact is that even as few as 48,000 workers of the 134,000 needed during the "peak" cannot be given year-round employment because of the varying nature of the required tasks beyond the capacity of individual workers and the widely separated areas offering employment.

The Washington Station, in a study in cooperation with the Federal Works Progress Administration, the Washington Works Progress Administration, and the Washington State Department of Public Welfare in the Yakima Valley, estimated that the total hired labor in 1935 was equivalent to over 1,260,000 10-hour days. The number of laborers required varied from 33,000 in the peak period to less than 500 in the slack period. Slightly more than twice as many resident as transient laborers were hired, the latter being needed chiefly for hop and apple picking. Of the transient laborers, over 38 percent were from the State, outside the Yakima Valley, 23 percent from drought-stricken States, and nearly 19 percent from Oregon and California. The median cash incomes were $350 for transient families, $275 for resident families, $335 for transient single workers, and $215 for resident single workers. Over 50 percent of the transient workers had no families, about one-third brought families with them, and 10 percent left their families elsewhere. Of the transients, about 20 percent of the single workers and 43 percent of the families had been on relief during the previous year.

F. G. Harden.

59024—38——12

SOCIAL CONDITIONS

Population trends in Minnesota.—In a study of population trends in the State, the Minnesota Station found that between 1820 and 1860 the population rose to 172,023 and by 1930 to 2,563,953. Of the latter figure, 51 percent was rural, while 49 percent was urban. In 1860, only 19.94 percent of the State's population were natives, while 45.9 percent were natives of other States, and 34.14 percent were foreign-born. Relatively few of the migrants into Minnesota were from the Southern and Western States, most of them coming from the Northern and Eastern States.

There has been a steady decrease in the size of families until 1930 when there was an average of 3.9 persons to a family. The birth rate had fallen from 24.7 in 1915 to 17.9 in 1932. From 1920 to 1930, births exceeded deaths by 287,217, yet the State's population increased but 176,828, indicating that a net migration from the State of 110,389 occurred. Only 1.2 percent of the population 10 years of age and over was classed as illiterate in 1930, when the white population constituted 99 percent of the total population of the State.

Rural population trends in Washington.—Between 1890 and 1930 the population grew from 357,232 to 1,563,396. During the decade 1910 to 1920, urban population outgrew rural population and the gap between the two has widened since that time. In 1930 the rural nonfarm population exceeded by about 78,500 the total farm population, when the rural population amounted to 678,857 and the urban 884,539. The urban population was increasing more rapidly than rural.

In 1890, 62 percent of the population was male and only 38 percent female, while in 1930 52.9 percent was male and 47.1 percent female. The rural areas have a higher proportion of males, whereas the more urbanized areas have a more even distribution of the sexes.

Washington State is low on marriage and high on divorced persons; low on married males and high on married females.

The birth rate declined from 19.8 percent in 1920 to 13.5 percent in 1932. The death rate decreased also, but only very slightly. The median size of family in the State in 1930 was only three persons per family.

Rural population and communities.—Results of studies by the Kentucky Station of migration of rural young people seem to indicate that a land-use policy in such areas as those studied must be based on the expectation that about one-third of the native youth may go into nearby better soil areas, one-third remain in the home area, and the others migrate to more distant places inside and outside of the State. The present index of natural increase of farm population in the area studied is 125 to 150. With an excess of only 25 to 50 percent and an emigration of more than 60 percent of the population, there is much opportunity for land-use adjustments.

Wisconsin rural youth education and occupation.—In a study of five sample counties in Wisconsin during the fall and winter of 1934, the educational and occupational status of rural youth was determined. Of 9,279 farm and village youth, 56.2 percent had received instruction amounting to the eighth grade or less, and 41.1 percent had attended high school or college. Of 3,814 who had received secondary and collegiate education, 16.3 percent had attended, but not been graduated from, high school, 56.7 percent were high-school graduates, and

27 percent had either graduated from high school or had college contacts. Twice as many of the farm youth per 100 as village youth had left high school before graduation.

Farming and homemaking on the farm were the chief occupations of rural youth in 1933, farming being followed by 73.6 percent of the farm young men whose homes were on the farm in 1928 and homemaking by 49.4 percent of the farm young women. In contrast, only 16.2 percent of the village young men and 8.8 percent of the village young women were similarly occupied. Over one-half of the farm young women had left the farm for pursuits in village or city, 39.7 percent of whom were housewives and 25.7 percent were in domestic or personal service. The young men from the farms were well scattered through the occupations, with "trades and sales" and "manufacturing and mechanics" the highest groups.

Rural youth of the ages 4 to 20 years were generally in school, comparatively few having completed their education or gone to work.

See also page 161.

Population mobility.—A study of 2,554 rural households located in 10 rural Ohio townships and 8 villages, covering the period 1928–35, showed that there was a net loss of population due to migration during the period 1930–35, except in the northeastern urbanized section. Households of greatest mobility were those in which the head of the household was under middle age. Relief families had made 40 percent more moves and 100 percent more changes of occupation than nonrelief. Of every 1,000 children 10 years of age or over in 1929 and living at home, 654 were still living at home in 1935. Of the latter, 48 percent of the males and 59 percent of the females were 21 years of age or over.

Between 1928 and 1935, every farm operator who left farming was replaced by three persons who were not farm operators in 1928. These new operators were drawn chiefly from the skilled, semiskilled, and unskilled occupational classes.

Characteristics of rural families in Michigan.—Of 741 Michigan rural families studied two-fifths had from 1 to 2 children, while 134 families had no children at all. In most instances, the families studied were amply housed. Nearly two-thirds of the houses had seven or more rooms, and the average number of rooms per person for the 527 rural families included in this study was 1.9. On the other hand, rural farm houses showed a marked absence of modern conveniences and rated considerably below the rural nonfarm houses in this respect. Farm-tenant houses were as large as those of farm owners, but a smaller proportion had modern conveniences, which were also less common in the houses of foreign-born families than in those of native-born.

The largest proportion of adults in these families had not gone beyond the eighth grade. Only about one-fourth of the husbands and one-third of the wives had attended high school. Fifty-four percent of the children were advanced, 32 percent had a normal school status, and 14 percent were one or more grades below normal.

Reading and listening to the radio occupied a large portion of the leisure time of the families studied. Three-fifths of the families had memberships in a church and one-half were represented in fraternal organizations. Seventy-nine of the 741 families studied held no memberships in any organization.

The standard of living of farm families.—A study of 376 Michigan farm families in selected dairy, fruit, potato, and general farming communities led to the following conclusions:

The average standard-of-living score for 240 of these families was 511 points out of a possible 1,000 points, the range being from 179 to 884. The variability was greatest for leadership, next for organizational affiliations, and least for family practices. The average farm practice score was 534, the range being from 222 to 790. The standards of living and farm practice ratings of 136 foreign-born families in which the operator was over 60 years of age or under 30, and of families in general farming communities operating less than 100 acres, were lower than for the 240 familes.

Farmers following the more efficient farm practices had incomes that were about three times as large as those with the less efficient practices. The standard of living was more closely correlated with farm practices than with income. More than one-half of the items contributing to a high standard of living required little or no cash outlay but rather depended upon the use of time in various family activities. Farmers having a high standard of living belonged to three times as many organizations as those with the low rating.

Adjustments made by most families during the depression were of two types: (1) 71 percent produced more of the family living on the farm; (2) adjustments requiring little or no expenditures of money, such as making more use of the opportunities furnished by the community and substitution of inexpensive types of recreation for more commercialized forms.

Social and economic status of farm families.—In a study of the social and economic status of farm families, the North Carolina Station found that although there appears to have been—

substantial improvement in the educational status among all farm groups, the differences in the educational status between various groups are surprisingly wide. Negro croppers and tenants in particular show a very low educational level. The educational status of family parents on relief was also found to be very low.

The disadvantaged farm family.—From a study of disadvantaged farm families, the Louisiana Station concludes in general that—

characteristics of the disadvantaged farm family are such that it will need a period of years for adequate adjustment. Since the general approach to the problem must be educational it appears that additional stress should be placed upon strengthening the existing educational agencies, particularly as they affect the households in question. The general objective of this education should be broad. It should not be limited to training for home ownership or for any other particular tenure status, since the data show these families may be disadvantaged as owners or as tenants or laborers as well. But the education should be directed at the enrichment of life in all its phases and under all its circumstances.

Part-time farming by Negroes.—A study by the Kentucky Station of the experience of Negroes engaged in part-time farming near Lexington, Ky., indicates that those who undertake part-time farming with the hope of financial gain are likely to be disappointed.

The chance to reduce the cost of living appears to be the chief advantage to be gained by living on a part-time farm. Cheaper food and housing make the part-time farm most attractive to large families with small incomes because such families spend a large share of their income for food and rent; besides, the children can help with the farm work and get recreation in the open country rather than in city streets.

In the study reported—

the total income of the 104 part-time operators averaged $399, of which $192, or 48 percent, was obtained from work done off the tracts. Farm receipts were 14 percent, food furnished from the tract 16 percent, and the value of the use of the dwelling was 17 percent of the total income. After expenses, including unpaid family labor and interest on investment, were deducted, the average earnings of the operator were $81. These earnings plus $204 outside income resulted in total labor earnings of $285 per operator. The amount of food for home use furnished from the tract showed little variation among the different outside-income groups and averaged about the same as the value of agricultural products sold from these tracts. Three-fourths of the total receipts from crops went to the 39 families having outside incomes of less than $125.

Rural housing in Louisiana.—Of the 16,403 homes surveyed, 10,333 were homes of white families and 6,070 were homes of colored families. Of the total, 6,055 were owned while 10,348 were rented. Of the white families, 51.8 percent owned their homes in comparison with 11.5 percent of the colored families. The percentage of new houses was higher among owners, both white and colored, than among tenants. Among tenants 53.4 percent of the whites lived in houses less than 25 years old compared with 45.6 percent of the colored tenants.

Of 16,403 rural houses, 98.3 percent were frame. The average number of rooms in each house was 4.2 and the average number of occupants 4.7. When it is considered that some of these rooms are kitchens, living rooms, dining rooms, it is realized that most of the rural houses lack sufficient bedrooms for each to be occupied by not more than two persons. Of the total number of houses studied, only 6.5 percent had bathrooms. Water was carried by the great majority of rural families, 2 percent had hand pumps, and 5.4 percent had cold water piped into the house, leaving 92.6 percent of the homes to which all water had to be carried. Very few of the homes had modern improvements.

Home ownership over the State generally is higher on poorer than on fertile soil.

Rural organizations.—The Kentucky Station has found that special-interest organizations were better suited to urban than to rural conditions. The study also indicated the wisdom of including both men and women in farm organizations or organizations appealing particularly to rural people.

The study further indicated that training and developing the members and leaders of rural organizations offers the surest method of developing the human resources of rural Kentucky and improving Kentucky agriculture as a way of life.

Suburbanization in Connecticut.—A significant trend in Connecticut in recent years has been the extensive movement of population into urban peripheries. The suburban movement has been predominantly one of white-collar and skilled workers seeking a good setting. The portion going into farming, however, has declined consistently during each five-year period since 1910. Only 11.8 percent of those moving during the period 1930–34 carried on farming activities.

Social and economic effects of soil erosion.—From a study of the influence of soil erosion on social organization, the Iowa Station concludes:

As erosion increases it is obvious that production demands more effort in both time and money. Erosion makes it more difficult for farmers to progress or even to hold their own. Increased effort and lack of progress are the first effects

of erosion. Lack of time and lack of economic returns make it more difficult for rural people to maintain needed organizations and a satisfying social life. Town and village centers decay, and on the farms there usually rushes in a class of farm renters, who are considered undesirable by the older residents, move from place to place, mine the soil, and are unresponsible to the community. Grown children in such families must leave home to find work because the head of the family can not save enough to retire and local employment is limited.

The general effect of conditions studied by the station in its surveys is stated to be—

one of social deterioration of social life, amounting almost to decadence, characterized by the general disorganization and disintegration of social life and social organizations.

Rehabilitation clients.—The Arkansas Station found rehabilitation clients' average age in that State to be 40 years. Rehabilitation clients were most numerous in the Ozark Mountain district in which from 15 to 25 percent of the rural families were included. All but 4.8 percent of the clients have been on the regular relief rolls, but the average time was slightly more than four months. The drought was given as the cause for needing assistance by 65 percent of the cases. In the Ozarks, 93 percent indicated drought as the cause. Forty percent of the clients were tenants, 17 owners, 18 croppers, and 19 percent nonfarmers.

The average size of household was 5.4 members. Households contained nearly twice as many children, but only one-third as many old people as the average American family. The birth rate in the group for 1934 was about three and one-half times the national average. Ninety-five percent of the clients lived in the open country. Overcrowded houses were typical. The average number of persons per room was 1.8 for both white and colored clients. A large majority lived in box and frame houses, averaging three rooms. In 1932, three-fourths of the clients lived on upland farms. Those producing cotton averaged 156 pounds per acre. Nonfarmers earned an average income of $199.66. They had inadequate equipment and livestock for efficient agriculture. Thirty percent had no canned goods and 78 percent had no cured meats. Eighty-five percent of them were in debt. Their average secured indebtedness was $190.23 and open accounts $55.90.

The clients had attended school on an average of 5.6 years. Five percent of them had no education.

Unemployment relief in Arizona.—In this study, covering the period from October 1, 1932, to December 31, 1936, it was found that employment in Arizona fell to a low point in the late fall of 1932 and early in 1933. About 3,300 men were employed in copper mines during 1933 compared with 16,000 men in 1929.

Seasonal agricultural employment was also low as shown by the total of 69,000 bales of cotton ginned for the crop season of 1932 compared with 115,000 ginned in the previous year and 152,000 ginned in 1929.

During October 1932, 6,000 persons were granted assistance through the Arizona Reconstruction Finance Corporation Commission and by the end of December 1932, 55,700 persons had received assistance amounting to $352,000. During the first 3 months of 1933 another $507,000 was obligated and by the end of June an additional $602,000. A total of $1,461,000 was expended largely for work on the public roads in the several counties, only $264,000 having been used for direct relief.

Marriage rate in rural North Carolina.—From a study of 1,703 families representing the two Piedmont areas and the Coastal Plain the following conclusions were reached:

During the depression years of 1932–34 in five counties surveyed the marriage rate of relief population was substantially lower than that of the nonrelief population. There was a highly significant correlation between the marriage rates and cotton prices of the previous year. Females married approximately 3 years earlier in life than males.

Beginning as early as 1927, marriage rates for Negroes, male and female, began to decline, whereas the marriage rates for white persons changed very little.

See also page 162.

B. Youngblood.

AGRICULTURAL ENGINEERING

Farm-commodity production operations and home-life processes and practices in many instances now require the use of various engineering principles for their most efficient performance. A few of the important typical examples of recent station accomplishments in agricultural engineering are here again recorded to illustrate its broader economic aspects and to indicate how engineering research is becoming an essential integral part of farm-commodity production and home-life investigations.

Farm power and mechanical equipment.—Farmers of the United States purchased more than $4,000,000 worth of mechanical farm equipment during 1936, according to the United States Bureau of the Census. This included planting, seeding, and fertilizing machinery, plows and listers, harrows, rollers, pulverizers and stalk cutters, cultivators and weeders, harvesting and haying machinery, tractors, stationary engines, wagons and trucks, machines for preparing crops for market or home use, and much miscellaneous farm machinery and equipment. This may be taken to indicate the tendency toward the wider adoption of mechanized farming practices to reduce costs and increase efficiency of production. The experiment stations have recognized and encouraged this tendency by studies aimed at the rational development of mechanized practices and the efficient adaptation of mechanical equipment to production.

Securing efficiency in the use of farm power.—Farming in the United States continues to use annually more power than any other industry except railway transportation. It is significant that of the amount expended by farmers during 1936 for mechanical equipment, nearly half, or about $186,000,000, was expended for tractors and stationary engines. In addition, Agricultural Statistics, 1937, show that there were 11,635,000 horses and mules on farms in the United States during 1936. The experiment stations have therefore recognized the necessity for studies aimed at increasing the efficiency of use of this vast amount of animal and mechanical power since most of it is employed in the traction operations of crop production and represents from 25 to 40 percent of the cost of production.

Typical of this work is that at the Missouri Station where studies have been in progress on various factors concerning the efficiency of horses, men, and motors and which have resulted in the establishment of a feeding standard for horses. For greatest power efficiency, it was found that optimum or best speed for maximum efficiency of

draft animals is a compromise between muscular viscosity, which requires slow movement for most efficient work, and overhead maintenance cost, which requires rapid movement for most efficient work. Efficiency tends to rise with increasing load until an optimum load and maximum efficiency are reached. The size of animal does not seem to influence maximum efficiency as all animals studied had approximately a 24-percent efficiency level. However, weight of the horse is the most important factor in pulling ability, according to the Illinois Station, and large heart girth, a moderate degree of flesh, and sharp shoes also contribute. Energy expenditures increase in direct proportion to speed of pulling given loads, with load pulled at given speeds, and with horse power. Horses and men apparently have the same work-energy to basal-energy ratios, namely, 20 for maximum oxygen consumption, 100 for maximum brief effort, and 8 for sustained hard work. It was found that the use of horse, mule, or mechanical power depends upon kind of work, availability of power, and feed or fuel for its operation.

In efforts to increase the efficiency of utilization of mechanical power for traction purposes, the stations have continued studies of rubber tires and steel drive wheels for tractors when performing practical farming operations. The Montana Station showed, for example, that fuel consumption of standard wheel tractors decreases slightly with heavy loads when the inflation pressure of the rubber tires is decreased and is less with rubber tires than with steel wheels by from 5 to 8 percent. Maximum drawbar pull and horsepower are higher with the larger sizes of rubber tires. Maximum drawbar pull also varies slightly with inflation pressure of rubber tires, being lower with the higher pressures. Maximum horsepower with rubber tires is greater in the higher gears. The addition of wheel weights with rubber tires increases both the maximum drawbar pull and the horsepower by an amount varying from one-third to two-thirds the value of the added weight. The maximum drawbar pull with steel wheels is greater for the lower gears and the maximum horsepower is about the same for all gears. The maximum drawbar pull and horsepower with large rubber tires are greater than with steel wheels but with the small rubber tires they are smaller. The slip of rubber tires is generally greater than that with steel wheels and lugs except with the lower inflation pressures. It appears that in high gear the tractor will pull larger loads when equipped with rubber tires than with steel wheels and the acre costs of operation with rubber tires are less in the high gears.

Similar studies were concentrated on the effect of tractor-tire size on drawbar pull by the Nebraska Station, the object being to get information especially on the effect of tire cross section. It was found on fine sandy corn soil and on wild-hay meadow stubble that an inflation pressure of 8 pounds gave greater traction than a 16-pound inflation pressure for several different sizes of tires. The 9 × 36 inch tire stood out as the best under most circumstances. It was evident that once the load becomes too heavy to be pulled in sandy soils, the tires with smaller cross sections dig in and bury themselves much more rapidly than those with larger cross sections. It was also found that tires having the largest effective wheel diameters yield the greatest horsepower. An effective method of holding a wheel tractor on lister ridges for early cultivation of listed corn was developed by the Iowa

Station by use of pneumatic tires. In this method, a single tire is used on one side of the tractor and is set to center on a lister ridge. A dual tire is used on the other side and straddles the ridge. With this equipment it was found that with the tractor wheels in the lister furrows the front wheels can easily be fixed onto the ridge by using the wheel brakes, and the rear wheels will climb the ridges from either side with no difficulty. Tires most adapted for this purpose were those of the 7.5 × 36 inch size.

The close dependence of economical operation of tractors on the type of fuel used and the manner of use is also being recognized by several of the stations. For example, tractors operate most efficiently near their rated capacity, according to the Montana Station, and it is important that proper carburetor adjustment be maintained. Excessive use of fuel may result from improper setting of the valves that regulate the ratio of fuel to air. A two-plow tractor should displace at least two horses and be used more than 300 hours per year if it is to be profitable, according to the Pennsylvania Station, and cost per hour rises rapidly when used less than 400 to 450 hours per year. In studies of tractor fuels in relation to tractor operating costs, the Wisconsin Station found that for uniformly steady loads equaling or exceeding 60 to 70 percent of the maximum horsepower of the engine, light straw-colored distillate of good grade having a maximum or end point of not over about 525° F. should be used. This recommendation applies to modern tractors equipped with good manifolding for the burning of heavy fuel and where provision is made for proper control of the engine temperature so as to maintain the temperature of the cooling medium above approximately 200°. Where the load on the engine is less than 60 or 70 percent of the minimum horsepower or where the loads are irregular as in the case of operating a silage cutter, the use of gasoline is recommended. The exclusive use of gasoline is recommended if the tractor is not used a large number of hours per year, and especially if it is a small tractor. It was ascertained that under such circumstances the economy of using distillate is not great.

Problems presented by the increasing use on farms of tractors equipped with engines of the low-compression type designed to burn a wide range of fuels also are being recognized by the experiment stations. Typical studies at the Kansas Station involved tests of five fuels of widely varying character in standard farm tractors. The results indicate that fuel consumption by volume is consistently lower with the low-grade fuels so that the greater weight per gallon of the low-grade fuels and their greater heat content per gallon result in economies in favor of kerosene and distillate in low-compression engines. It was also not uncommon to obtain a greater energy output per gallon of fuel burned with the lower grade fuels in the low-grade fuel-burning tractor. In such tractors, fuel costs were about 40 percent less with distillate than where a regular grade of gasoline was used. It was found, however, that operation of the tractor engine is erratic on loads of one-half or less of the rated power when burning kerosene or distillate. In actual plowing tests there was slight detonation when burning kerosene, but less of this fuel was used per acre than of other fuels, it being indicated that lower fuel consumption will be obtained with low-grade fuels when slight detonation occurs. In general, on a gallon-per-acre basis for a low-compression tractor, the advantage is with the low-grade fuels, largely due to their greater

weight and lower price per gallon. Excessive dilution of crankcase oil in tractors when low-grade fuels are used, together with much of the wear on engine parts, can be reduced by the use of gasoline, according to the Illinois Station. That station also demonstrated that high-compression engines for tractors show economies in fuel use.

In further efforts to introduce economy into tractor fuels, various farm-waste materials have been successfully tested by the Idaho Station for the production of commercial fuel alcohol and also of alcohol-gasoline blends for fuel.

More efficient tillage methods and equipment.—Tillage continues to be the greatest consumer of power of any of the draft operations on the farm, and the experiment stations have continued studies aimed at the more efficient use of available tillage tools and the development of the principles of design of new tillage equipment needed to accomplish this operation more economically. Typical of this work is that in progress at the Alabama Station in cooperation with the Department of Agriculture (B. A. Eng.). In this work it has been found possible to evaluate and correlate the dynamic properties of the soil and the shape of plows and the methods of their operation in a way which has resulted not only in more efficient use of available moldboard plow shapes but in the development of the principles governing the shape of moldboards essential to the performance of efficient tillage under especially difficult soil conditions. The identification and utilization of useful soil forces on tillage tools is being gradually reduced to an exact mechanical science by the Pennsylvania Station with the result that combinations of tillage tools have been developed to increase the efficiency and economy of the tillage operation. The station has found that the commonly used center-of-resistance rule for plow hitches is erroneous, and a new rule has been developed which is of more universal and accurate application. Specialized tillage problems are also being considered by the experiment stations. A typical instance is the development of a practical cultivating tool for blueberries by the New Jersey Station. In this work tillage close to the plant by means of ordinary cultivators was found impracticable, and root pruning by deep cultivation checked plant development. The practice of mounding also presented the need for a tool that is automatically adjustable to varying combinations of sloping and flat surfaces, and a new harrow was developed to meet these requirements.

Most efficient mechanical fertilizer placement.—Farmers in the United States are now using in the neighborhood of 8,000,000 tons of fertilizers annually, and their placement on crops to secure maximum effectiveness with minimum cost and minimum injury to plants has an important bearing on the total cost of production. Mechanical application methods to reduce labor costs of application have been increasingly developed by at least 14 of the experiment stations, usually in cooperation with the Department of Agriculture (B. A. Eng.) and other organized national groups.

Typical investigations with snap beans, peas, kale, spinach, onions, tomatoes, early cabbage, and Fordhook lima beans by the Virginia Truck Station, in which special attention was devoted to the effect of placement on germination of seed and yield, showed that fertilizer applied in the row either directly beneath the seed or mixed with the soil in the row reduces germination and in most cases re-

duces yields. Application in bands from 1 to 2 inches on each side of the seed and 1 or 2 inches below the level of the seed has, in general, been less injurious to germination and given higher yields than other methods of application. In a few instances broadcast treatment has proved as satisfactory as application in bands, but this method of application is not generally recommended. Results with transplanted plants such as tomatoes and cabbage indicate that placement in bands may not be as satisfactory as applying a part of the fertilizer in the row and mixing with the soil before planting and side dressing later in rather wide bands on both sides of the row followed by thorough mixing of the fertilizer with the soil by cultivation.

Cotton is one of the largest consumers of fertilizers, and to attain efficiency in this practice machine placement of fertilizers on cotton has been studied widely in the Cotton Belt. Typical of these investigations is that at the Texas Station, in cooperation with the Department of Agriculure (B. A. Eng.), which indicates that the earliest germination, the highest average percentage of seedlings emerging, the best final stand of plants, and the most rapid growth are obtained when the fertilizer is applied 2.5 inches to the sides and 2 inches below the seed level. Experiments on the mechanical application of fertilizers to cannery peas at the New York State Station resulted in the development of an attachment for a grain drill by means of which fertilizer and seed may be sown in one operation but with the fertilizer so placed as not to injure the seed. Placement of superphosphate 2.5 inches to the side and 1 inch lower than the seed has proved particularly effective. The results of 10 different studies on the machine placement of fertilizers for snap beans in Florida by the Florida Station, in cooperation with the Department of Agriculture (B. A. Eng.), showed that earliest germination, best stands, most rapid growth of plants, earliest maturity, and highest yields of green beans both at first picking and at final harvest are obtained with fertilizer placements in a band 3 inches under the seed and in a narrow band 2 inches to each side of the seed row, 1.5 inches below the level of the seed. Special attachments were developed at the Ohio Station to permit the placement of bands of fertilizer at seed level and at a considerable depth below the seed plane when planting seed corn.

Better mechanical planting of field crops.—The cost of seed for the planting of extensive field crops such as corn, cotton, beans, and other row crops is a considerable item in the total cost of production of such crops. The labor cost of planting also is of considerable importance so that the stations have investigated the mechanical planting of field crops with the idea of securing maximum germination and stands with a minimum cost for labor and power.

Typical of this work in the Corn Belt is that at the Ohio Station where combination planting and fertilizer application has been developed to a high degree and the planting mechanisms particularly have been developed to attain the most efficient use of seed with maximum germination and stand. Studies of the calibration of cotton-planting mechanism by the Texas Station showed that the size of seed materially influences the quantity of seed dropped. It appears that the number of plants obtained with cell-drop planting

mechanisms will range from 2 to 12 per foot, and to obtain a perfect stand of 14,520 plants per acre from 1 to 11 plants per foot must be thinned out. The number of plants per foot for picker-wheel drop mechanisms ranges from 2 to 27, requiring the removal of from 1 to 26 plants per foot to leave 1 plant per foot. On this basis a calibration scheme was worked out by the station for obtaining the desired stand. A chain drop planter has been developed by the California Station to give uniform distribution of sugar beet seed in drilled rows. Satisfactory stands have been obtained with seeding rates as low as 5 pounds per acre, and the method shows promise of reducing labor costs during thinning.

Mechanical harvesting.—The harvesting of crops, including especially the grains, has received much attention by the experiment stations for many years and mechanical equipment for efficient harvesting at a minimum cost has been developed and placed on the market by manufacturers. The harvesting of the seed of different crops has offered special problems in view of the necessity for retaining the quality of high-percentage germination. The threshing of such seed as lima bean seed has received special attention. For example, the State of California alone produces annually several million pounds of both large and small lima bean seed, much of which goes to Eastern States where it is used for market, garden, or canning crops. Difficulty has been experienced in securing good stands of lima beans because of poor germination resulting from mechanical injury to the seed during threshing or handling. To meet this situation, a rubber-roller cylinder seed-bean thresher was developed by the California Station. It was found that 99 percent of the beans passing through this thresher are of salable seed quality. Preliminary tests also show that this new principle of bean threshing is applicable to seed-pea harvesting. In like manner, a flax thresher for the harvesting of seed was developed by the California Station which has proved quite adequate as well as saving of time and labor. It consists of a seed table, two rubber-covered rollers, and a cleaning shoe of standard construction. The upper roller is mounted on bearings which are in turn mounted in guides which permit the upper roller to raise when wads of flax straw pass through. The top roller is driven at 105 revolutions per minute and the lower roller at 95 revolutions per minute. This differential in speed when coupled with the pressure on the roller produces a rubbing as well as a crushing action which breaks the flax bolls and rubs out the seed.

The Texas Station has developed a stripper-type cotton harvester which gives reasonably satisfactory performance and is adapted especially to the semiarid, short-season, low-yielding cotton areas of the High Plains. The stripper harvester is a relatively simple low-cost machine which can be operated by comparatively unskilled labor. The stripper is essentially a once-over machine, and much trash is gathered along with stripped or sledded cotton. This problem is being overcome by the development of special gin equipment. The first cost of a home-made stripper is small and even the factory-built machines with stripping rolls cost only from $200 to $300 for a single-row machine. The average useful life of a stripper is estimated at 10 years and the annual repair cost is relatively low. The power requirements are also low, and a one-row stripper will gather as much cotton as six or seven hand snappers, making the overhead and oper-

ating costs per bale low, even though the stripper is used on low-yielding cotton.

Mechanical curing and processing of feeds.—In order to secure the highest nutritive value from feeds for farm animals, work has been done by several of the stations on methods of curing and storage which will conserve these crops to the highest degree. This has called for extensive cooperation with specialists in plant physiology and in animal nutrition. Typical of this work is that done on the field-curing of Johnson grass and soybean hay by the Mississippi Station under severe conditions of weather. In this work a mower-crusher machine was developed by the station which has been used with satisfactory results in speeding up the natural curing of hay and thus minimizing the danger of damage by rains. The possibility and practicability of cutting and curing hay in one day were demonstrated under highly humid conditions by cutting and crushing it with this machine. It was found that the moisture content of crushed Johnson grass hay dropped from 73.1 percent to 10.9 percent in 4 hours while the moisture content of uncrushed hay decreased to only 49.1 percent. The cutting and crushing are done in one operation, thus conserving labor.

The advantage of chopping alfalfa hay before storing it in the barn has been demonstrated by the Indiana Station. Hay containing as much as 19 percent of moisture at the time of cutting was stored successfully without loss of a good green color. The chopped hay was more easily handled and was easier to feed than long hay and slightly less time was required to store the hay by chopping than in the regular way. Hay can be cured in the field and successfully chopped and blown into the mow by a hay chopper, according to the Iowa Station. The cost per ton by this process is slightly more than when it is mowed and handled with the grapple fork. Hay with a high moisture content is relatively more expensive to handle in this manner than hay with a low moisture content. The economy and effectiveness of artificial drying of hay chopped into a small metal silo were also successfully demonstrated by the Connecticut (Storrs) Station.

The bin method of drying seed corn was developed to a successful status by the Wisconsin Station. Likewise, the dehydration of ear corn was successfully developed by the Oregon Station, it being demonstrated that the problem is a simple one of forcing heated air through kilns of ear corn having a depth of from 2 to 3 feet. For drying ear corn to be used for feeding, it was demonstrated that the maximum temperature of the air from the furnace may be 175° F. Satisfactory drying was accomplished by using from 75 to 100 cubic feet of air per minute per square foot of kiln area. It is also possible to recirculate from 50 to 75 percent of the air in the drying system, thus saving from 45 to 60 percent of the fuel required with no decrease in the speed of drying.

The material aid to animal nutrition by grinding feeds to certain degrees of fineness corresponding to the needs of particular types and breeds of animals continued to be recognized by several of the stations. In general, it has been found that grinding grain increases its value as a feed for livestock about 10 percent, and that if the total cost of grinding any grain exceeds 10 percent of the cost of the grain during a feeding period the profit from grinding the grain to increase its feeding value is questionable. It appears that where

resort is made to mixtures for different rations, the cost of grinding must be based on the advantage of a proper mixture rather than on comparisons of the values of whole or ground grains. Recognizing the need for a feed grinder to operate on 1 horsepower or less, studies of desirable and possible designs and operating characteristics of such equipment have been undertaken by several of the experiment stations. Typical of this work is that at the Tennessee Station, where the principles of small automatic hammer mills have been developed to meet the situation. From this work, the design of a new low-power hammer mill was developed to meet the needs of those who can use such a grinder to advantage.

See also page 47.

Portable seed-cleaning equipment.—The importance of cleaning and treating seed in the major grain-growing sections to remove noxious weed seed and decrease diseases has been recognized by the stations. The equipment available to the average farmer is a small-farm-type fanning mill of his own or the receiving separator of the nearest elevator. In view of the inadequacy of such equipment, the stations have attempted to develop portable equipment of more satisfactory character. Typical of this work is that at the Indiana Station where equipment has been developed which provides the services of improved cleaning and treating. It has been found more economical to transport the equipment to the grain than to bring the grain to a central point. Such equipment reduces labor costs by making all operations such as weighing and sacking automatic.

Stationary spraying equipment.—Stationary spraying equipment has made possible the timely application of sprays under weather conditions unfavorable for the use of portable spray outfits. Under conditions in some States, stationary equipment has been found to reduce the cost of spraying substantially as compared with the cost of portable sprayers. However, the stations are continuing efforts to increase the efficiency of this equipment by further improvement of some of its mechanical details. For example, stationary spray plants must be designed to operate at all times above the critical region of spray material sedimentation in distribution pipes, according to the Illinois Station, and suitable velocities of operation for different conditions have been established. Stationary spraying equipment has been successfully adapted by the Ohio Station, especially for orchards on steep lands. This equipment has been found to eliminate the need of a heavy expensive wheel truck for transportation and does not require any draft power.

Weed-control equipment.—The control of weeds continues to be one of the major problems of the American farmer, and representative stations of the major regions have continued investigations to develop both biological and mechanical practices which will give permanent control. Typical of the mechanical developments is that by the South Dakota Station, where it was found that the two-row cultivator can be converted easily and quickly into a weed-control machine which is satisfactory both for weed control or summer fallowing. The type of cultivator which lends itself best to this conversion is the two-row shovel-type horse-drawn machine.

See also page 19.

Erosion-control methods and equipment.—The development of erosion-control measures, including especially those of a mechanical

character, has been continued by practically all of the stations, particular attention being devoted to the economics of such practices. Typical of this work are studies recently completed by the Ohio Station on the effect of land use and management on erosion. It appears that erosion is associated primarily with type of farming. According to observations on 100 farms located in four Soil Conservation Service demonstration areas, erosion also reduces crop yields. Incomes were 65 percent larger on the less-eroded farms than on the more severely eroded farms. The average cost of protecting an acre of land with terraces built by eight cooperative terracing associations was found by the Virginia Station to be $1.44 and there were indications that this figure could be reduced with experience. The evidence showed that even at a cost of $2 per acre, the building of terraces was a worthwhile investment.

Poorly planned terraces and terrace outlets have in most cases been unsatisfactory, according to the Illinois Station, and progress has been made in the perfecting of mechanical checks of soil washing. The most satisfactory terrace grades in the State range from 1 to 4 inches in 100 feet, with all terraces more than three to four hundred feet long constructed to a variable grade. While in certain exceedingly porous soils level terraces with closed ends have been found to perform satisfactorily, it is recognized by the station that level terraces have a very limited place in Illinois. It appears that little maintenance of terraces is needed when plowing, planting, and cultivating of crops are done on the contour. Furthermore, contour cultivation tends to reduce erosion between terraces. A contour plow has been devised by the Iowa Station which provides a comparatively simple means of building contour ridges in sodded pastures without destroying any of the sod and leaving a minimum of unsodded earth exposed.

The use of the terracing plow for soil-erosion control has been further developed by the Oklahoma Station, it being found that the effective height for terrace ridges can be increased by plowing twice in the same furrow for three or four rounds. A moldboard designed with the outer end flattened and bent slightly to the rear at a point about 22 inches from the edge of the land side will operate easier along crooked furrows in soil where clods are frequently encountered and in soil which tends to stick near the end of a straight moldboard. When terrace ridges are being constructed with a terracing plow, the land should be planted to small grain or some other crop which will cover the surface of the ground and reduce the erosion which may occur from breaks in the row ridges. When row crops are grown, the rows should be planted on a contour and parallel with the terrace ridge. The terracing plow was found to be more useful than a backfilling plow or an ordinary plow in gully control. Soil-saving dams for use in gully control have been developed to a satisfactory status by the Wisconsin Station. It has been found that the value of soil-saving dams is measured directly by the price of the farm on which it is installed.

After 16 years of measurements of erosion and run-off under different systems of cropping and cultural practices, the Missouri Station investigated continuous fallow on soils in order to measure the effect of previous cropping and cultural practices. Under the 3 years of fallow, the previously cropped plats lost more soil under

fallow than under the cropping systems. Soil which was originally not sodded showed particularly low run-off and erosion. Under continuous corn cropping, increasing the slope from 3.68 to 6 percent and to 8½ percent increased the erosion losses under fallow about three and five times, respectively. Slopes of various lengths but with the same degree of slope showed decreased run-off and increased erosion with the longer slopes. Several years' comparison of run-off and erosion in prairie pasture and cultivated land by the Nebraska Station showed that water penetration is nearly four times as great in prairie as in pasture and that soil covered with its natural mantle of climax vegetation represents conditions most favorable to the maximum absorption of rainfall and maximum erosion control.

Cropping systems which are effective in the control of soil erosion have been developed by the Missouri Station. It appears that the standard rotations consisting of 1 or 2 years of corn, 1 or 2 years of small grain, and 1 or 2 years of clover or clover and grass represent some of the most effective cropping systems for controlling erosion. Various combinations of small-grain crops and Korean lespedeza offer special promise in erosion control under Missouri conditions. Contour planting of row crops and strip cropping are other cropping practices recommended. These practices together with the use of winter cover crops were also found by the Alabama Station to reduce sheet erosion on clay soils, especially where tillage practices which increase the rate and amount of rainfall absorption have been used. The detrimental effect of wind erosion and improper cultivation on southern High Plains soils as regards total nitrogen and organic-matter content was demonstrated by the Oklahoma Station. Since the total nitrogen and organic matter decrease rapidly with depth, it is necessary to retain the surface soil with a minimum of disturbance.

Improved farm buildings and structural equipment.—The investment in buildings and production structures on farms in the United States continues to be one of the largest of the farm physical plant. Practically all of the stations have recognized the necessity of studies to increase the efficient utilization of buildings already on farms and to improve the design of new buildings to make them factors in reduced cost of agricultural production.

Poultry buildings.—Typical of the efforts of the experiment stations to modernize poultry buildings for farms is the work at the Pennsylvania Station on air-conditioned poultry brooder houses. It appears that insulation plays an important part in maintaining desirable temperatures and humidity in poultry brooder houses, particularly under the severe winter conditions prevailing in parts of Pennsylvania. It was found impossible to hold such brooder houses at a temperature of 35° F. without refrigeration even in winter brooding, and there was a wide difference in relative humidity between insulated and uninsulated houses when moisture was not supplied in the insulated houses. In the development of equipment for such houses, an effective brooder which poultrymen can make at home and operate in safety has been devised and made available to farmers by the Oregon Station. It is significant that since the plans for this equipment were made known, approximately 500 such brooders have been constructed by farmers according to specifications issued by the station.

Rammed-earth construction.—Efforts to introduce economy into farm-building construction by the utilization of local materials have

been continued by the stations. For example, specifications are now available from the South Dakota Station for rammed-earth construction suitable for such buildings as poultry houses, grain storages, and other production buildings, which include information regarding soil texture, warping, foundations, and other requirements. It has been demonstrated that soil low in colloids is favorable to rammed-earth walls and resists weathering action, and a testing procedure for colloids has been developed which not only identifies the soil as being favorable or unfavorable for this purpose but indicates just how favorable it will be. The dividing line between favorable and unfavorable soils was found to be a colloid content of 40 percent. Clay soil is not favorable for rammed-earth walls in spite of its superior strength because it has a tendency to slake in the wall and is not resistant to weathering.

General-purpose barns.—The general-purpose barn is the most widely used farm structure and is one of the large items in the total investment for physical plant on the farm. Efforts have been under way at a number of the stations for several years to develop designs of general-purpose barns which would introduce permanence and ultimate economy in construction as well as efficiency in use. Typical of such investigations are those of the Iowa Station, which has developed a successful design of an all-masonry barn which may be constructed at reasonable first cost and which has all the advantages of permanent and fire-resistant construction. It was found that the roof is the most important feature of this structure, and the additional cost of the roof over wood-frame construction is due not so much to the cost of the materials as to the cost of handling the materials and in manipulating the forms for the concrete. The practical application of air conditioning to apple storage, two-story poultry houses, and sheep barns used for hothouse lamb production has been demonstrated by the Wisconsin Station.

Preservation of fence posts.—Fencing materials have been found to be an important factor in the cost of farm physical equipment, and a number of the stations have studied methods of treatment of posts to increase their durability and thereby reduce their ultimate cost. In comparative tests extending over a number of years with various preservatives, especially carbolineum and creosote, the Missouri Station has found that Osage-orange, catalpa, white cedar, black locust, white oak, and sassafras posts give satisfactory use without treatment. White walnut, white elm, honeylocust, yellow pine, and red cedar posts give more satisfactory results when treated with carbolineum. If the maximum allowable cost for treatment per post per year is established at 1¾ cents, only a limited number of varieties and treatments are feasible. The Oregon Station has found that treatment of green posts with a solution of equal parts by weight of corrosive sublimate, arsenic, and common salt is an effective means of preservation. It is important that green post material be used, since the efficiency of the treatment depends upon the amount of moisture in the post. This moisture dissolves the salts and carries them through the fibers of the wood.

The open-tank process of creosoting native posts was developed to the successful stage by the Connecticut (State) Station, it being found that oak is quite readily impregnated to a depth of 0.25 inch

at the ground line if immersed in creosote at a temperature of 215° to 220° F. from 4 to 6 hours. Unless the tops of the posts are to be banded they should be dipped for from 5 to 10 minutes in hot creosote. Red maple and birch can be impregnated to a depth of 0.25 inch at the ground line with the prolonged hot bath of 12 hours or more, but with this duration of bath, the post butts absorb an excess of preservative that serves no useful purpose and very materially increases the cost of treatment. To overcome this difficulty, posts of these species should be perforated with a toothed hammer for 6 inches above and 18 inches below the ground line.

Methods and equipment for farm irrigation.—The recurring droughts of the past few years have emphasized the necessity for the stations to secure more precise information regarding the best utilization of water in irrigation, not only under arid conditions, but particularly under humid conditions where irrigation to supplement rainfall may be necessary to save crops during periods of dry weather. For example, the porous-hose method of irrigation, which was originally developed at the Michigan Station, has been improved by the Ohio Station in a manner which speeds up the flow of water and improves the process. The rotary spray system of irrigation has been developed in its mechanical details by the Michigan Station so that it can now be used with satisfaction and economy.

Pump irrigation has been developed to a satisfactory status for the production of crops under conditions approximating general farm practice by the Nebraska Station. Eleven years of experimental work have demonstrated the economy of this practice for western Nebraska farming. To meet the practical requirements of irrigation practices in the arid regions of the Southwest, the New Mexico Station has issued practical information, based upon extensive studies of water resources, on the development and sinking of wells for farm-irrigation pumping.

Recognizing the economic necessity of more accurate measurement of irrigation water, the Colorado Station cooperating with the Department of Agriculture (B. A. Eng.) has developed the Parshall measuring flume so that in field operation it is practical under conditions which make a standard weir or rating flume impractical, either because of silting trouble or insufficient grade. The accuracy of measurement with this device is entirely within practical limits.

See also page 25.

Use of electricity in agriculture.—The continued stimulus given to line building for the distribution of electricity to rural and farm areas has resulted in increased efforts by the stations to adapt electricity to production operations and household uses on farms. At the end of 1936 nearly 1,043,000 farms in the United States were connected to central-station service, this representing an increase of between 100,000 and 115,000 farms so connected over the previous year. Under the circumstances it becomes necessary not only to increase the efficiency with which electricity is used on farms but also to increase the total efficiently used electrical load in order to secure the advantages of lower rates. Thus the stations not only have improved old uses along cost-saving lines but have developed several new uses.

Hotbed heating by electricity.—In line with efforts at cost saving in the rural use of electricity considerable work has been done by the stations on improving the practice of heating hotbeds with electric-

ity. A typical accomplishment is the demonstration by the Pennsylvania Station that proper insulation and weather stripping of electrically heated hotbed frames will reduce the energy consumption approximately one-half as compared with similar frames not insulated or weather stripped. Much heat can be saved by use of covers over the glass at night and when the sun is not shining, according to the Kansas Station, and heat losses through the side walls can be decreased measurably by setting the bed low in the ground and banking the space around the bed with straw. The use of cinder insulation under and around beds shows a saving of 20 percent in the amount of electricity used, according to the Indiana Station.

Electric brooders for chicks.—In similar efforts to introduce greater economy into electric chick brooders the Virginia Station demonstrated that nothing is to be gained by converting old hovers into electric brooders because of the excessive current consumption. The station has designed a home-made electric brooder which gives good brooding results with an average current consumption and the total cost of which, exclusive of labor, is approximately $10. The most efficient sizes of electric hover are for Leghorns, 10 square inches of hover area for each chick; for heavier breeds, 12 square inches for each chick; and for turkeys, 20 square inches for each poult, according to the New York (Cornell) Station. The size of brooder room should be for Leghorns, one-half square foot of floor area for each chick; for heavier breeds, five-eighths of a square foot for each chick; and for turkeys, 1 square foot for each poult. For electric brooding in fall, winter, and early spring a brooder room temperature of 45° to 50° F. is desirable. The electric brooder-hover has been developed so that the labor required to care for the chicks is about 25 percent less than that required with a coal-heated hover. The fire danger is also decreased.

Artificial light for flowers.—Among the newer and more promising uses of electricity, the application of artificial illumination of greenhouse crops, particularly flowers, stands out prominently. Typical of such work by the stations is the demonstration by the Ohio Station that the flowering period of chrysanthemums may be prolonged by the use of supplementary illumination. Additional light applied before August 15 and discontinued October 1 has been found most effective in retarding flower bud differentiation of the chrysanthemum. Mazda lamps installed to emit at least 3 foot-candles at the furthermost point from the lamp are more satisfactory in this respect than daylight, medium and light blue lamps, and mercury lamps. Increasing the day length to 15 hours by such means is sufficient to retard flowering.

R. W. Trullinger.

STATISTICS OF EXPERIMENT STATIONS, 1937

By J. I. Schulte

The following tables give detailed data regarding personnel, publications, and mailing lists; income; expenditures from Hatch, Adams, Purnell, Bankhead-Jones, and supplementary funds; additions to equipment; and total disbursements from the United States Treasury under the Hatch, Adams, Purnell, and Bankhead-Jones Acts from their passage to the end of the fiscal year, June 30, 1937.

TABLE 4.—*Personnel, publications, and mailing lists of the experiment stations for the year ended June 30, 1937*

Station	Date of organization under Hatch Act	Number on staff	Teachers on staff	Staff members assisting in extension work	Publications						Names on mailing list
					Station publications		Articles in scientific journals		Miscellaneous publications		
					Number	Pages	Number	Pages	Number	Pages	
Alabama	Feb. 24, 1888	58	30		5	96	8	102			4,200
Alaska	July 1, 1931	3	2		4	157					479
Arizona	July 1, 1889	49	36	1	8	377	28	28	10	10	221
Arkansas	Apr. 2, 1888	63	51	4	13	589	24	24			5,135
California	March 1888	246	140		26	1,168	264	2,421	203	1,772	4,535
Colorado	Feb. 29, 1888	69	40	1	14	421	13	87	2	11	550
Connecticut:											
State	May 18, 1887	43			14	708	42	168	3	14	14,277
Storrs	do	33	14	5	8	600	27	162			11,000
Delaware	Feb. 21, 1888	25	9	7	4	274					11,000
Florida	March 1888	89	13	9	20	625	25	25	35	105	18,500
Georgia	July 1, 1889	36			9	161	4	31	1	5	7,500
Hawaii	July 1, 1929	35	12	2	3	236	8	45	10	45	1,774
Idaho	Feb. 26, 1892	56	37	8	3	122	4	21			21,500
Illinois	Mar. 21, 1888	136	76	10	35	1,808	190	1,272	13	42	30,300
Indiana	January 1888	110	30	5	37	1,091	104	440	18	125	37,412
Iowa	Feb. 17, 1888	146	84	10	33	1,765	76	522	76	522	23,057
Kansas	Feb. 8, 1888	117	91	1	8	426	91	91			12,000
Kentucky	April 1888	54	30	7	16	522	28	28			6,000
Louisiana	Apr. 5, 1887	62	14	2	19	371					6,000
Maine	Oct. 1, 1887	41	6		8	542	5	28	1	28	15,600
Maryland	April 1888	63	38	12	14	1,136	38	38	3	9	20,000
Massachusetts	Mar. 2, 1888	84	18		22	487	26	164			1,600
Michigan	Feb. 26, 1888	133	78	11	37	378	37	378			14,000
Minnesota	——— 1888	148	111	4	15	609	85	875	25	80	1,322
Mississippi	Jan. 27, 1888	61	25	3	7	303			10	18	20,000
Missouri	January 1888	84	71	3	45	1,556	46	46			2,114
Montana	July 1, 1893	48	20	6	22	1,063	12	52			2,000
Nebraska	June 13, 1887	64	42		17	563					1,350
Nevada	December 1887	21	2		3	69	4	4			4,500
New Hampshire	Aug. 4, 1887	54	28	8	23	386					8,000
New Jersey:											
College	Apr. 26, 1888	54	39	1	28	750	76	76	2	56	11,576
State		[1] 86									
New Mexico	Dec. 14, 1889	31	24	1	39	425	2	1			12,000
New York:											
Cornell	April 1888	159	114	9	44	1,753	264	1,584			49,031
State	do	78			23	547	57	57	4	56	17,250

North Carolina	Mar. 7, 1887	62	22	5	16	493	9	478	3	129	7,350
North Dakota	March 1890	53	29	4	2	48	9	76			17,000
Ohio	Apr. 2, 1888	94			23	846	55	320			32,343
Oklahoma	Oct. 27, 1890	65	50	1	9	412					6,703
Oregon	July 1888	98	48	7	7	136	16	207	17	116	1,800
Pennsylvania	June 30, 1887	146	146		17	702	26	184	38	38	30,000
Puerto Rico	Aug. 16, 1933	37			8	770					2,268
Rhode Island	July 30, 1888	27	15	5	6	229					4,000
South Carolina	January 1888	60	18	2	8	409	6	6			5,000
South Dakota	Mar. 13, 1887	37	34	3	17	686	16	74			2,487
Tennessee	Aug. 4, 1887	49	16		18	220	1	11			19,302
Texas	Jan. 25, 1888	133	1	1	19	1,146	12	100			80,638
Utah	Nov. 16, 1889	42	28	5	10	402	39	187			3,986
Vermont	Feb. 28, 1888	30	11		17	537	15	120			4,000
Virginia	March 1888	55	21	5	6	106	24	101			12,000
Washington	May 22, 1891	64	31		31	814	33	261	5	78	1,924
West Virginia	June 11, 1888	50	29	7	10	369					12,000
Wisconsin	July 1, 1887	157	107	41	3	207	181	181			37,500
Wyoming	Mar. 1, 1891	41	24	1	7	293	12	57	9	18	8,750
Total		3,924	1,955	217	860	30,909	2,042	11,133	488	3,277	684,834

[1] Including 15 who are also on the college station staff but not duplicated in the total.

TABLE 5.—*Experiment station income for the year ended June 30, 1937*

Station	Federal grants					Supplementary							Grand total
	Hatch fund	Adams fund	Purnell fund	Bankhead-Jones fund	Total	Balance from previous year	State appropriations	Special endowments, industrial fellowships, etc.	Fees	Sales	Miscellaneous	Total	
Alabama	$15,000	$15,000	$60,000	$41,347.56	$131,347.56	$103,657.09	$128,038.65	$1,500.00	----------	$59,376.38	$7,954.30	$ 300,526.42	$431,873.98
Alaska	15,000	----------	----------	1,118.24	16,118.24	1,302.10	4,000.00	----------	----------	3,908.87	----------	9,210.97	25,329.21
Arizona	15,000	15,000	60,000	6,211.28	96,211.28	3,221.41	102,193.81	----------	----------	2,379.50	----------	107,794.72	204,006.00
Arkansas	15,000	15,000	60,000	31,991.60	121,991.60	----------	66,473.74	1,250.00	----------	25,219.28	----------	92,943.02	214,934.62
California	15,000	15,000	60,000	32,970.98	122,970.98	15,833.64	812,937.71	78,317.20	----------	52,057.62	----------	959,146.17	1,082,117.15
Colorado	15,000	15,000	60,000	11,215.48	101,215.48	49,263.40	81,177.78	----------	----------	----------	48,241.98	178,683.16	279,898.64
Connecticut:													
State	7,500	7,500	30,000	5,164.52	50,164.52	----------	214,452.67	8,000.00	$24,500.00	----------	----------	246,952.67	297,117.19
Storrs	7,500	7,500	30,000	5,164.52	50,164.52	----------	40,981.60	----------	6,373.81	1,577.63	----------	48,933.04	99,097.56
Delaware	15,000	15,000	60,000	2,505.10	92,505.10	4,483.52	21,061.71	----------	----------	17,219.67	----------	42,764.90	135,270.00
Florida	15,000	15,000	60,000	15,400.82	105,400.82	61,607.41	370,299.20	----------	----------	41,112.66	----------	473,019.27	578,420.09
Georgia	15,000	15,000	60,000	43,761.46	133,761.46	9,545.28	18,350.33	----------	----------	19,546.34	8,639.10	56,081.05	189,842.51
Hawaii [1]	15,000	15,000	20,000	4,593.20	54,593.20	1,108.22	----------	----------	----------	18,354.18	27,005.93	46,468.33	101,061.53
Idaho	15,000	15,000	60,000	6,859.28	96,859.28	1,939.10	20,404.67	----------	----------	32,072.79	----------	54,416.56	151,275.84
Illinois [2]	15,000	15,000	60,000	43,368.26	133,368.26	----------	364,356.98	17,883.08	----------	53,612.89	----------	435,852.95	569,221.21
Indiana [2]	15,000	15,000	60,000	31,361.30	121,361.30	295,417.91	225,000.00	84,965.35	186,531.29	130,555.33	36,064.22	958,534.10	1,079,895.40
Iowa	15,000	15,000	60,000	32,427.32	122,427.32	16,861.75	209,582.19	19,978.93	----------	45,644.02	----------	292,066.89	414,494.21
Kansas	15,000	15,000	60,000	25,025.48	115,025.48	15,855.12	108,502.41	----------	62,617.25	----------	1,889.00	188,863.78	303,889.26
Kentucky	15,000	15,000	60,000	39,469.02	129,469.02	8,855.07	99,000.00	----------	146,276.34	50,456.47	1,860.89	306,448.77	435,917.79
Louisiana	15,000	15,000	60,000	27,566.72	117,566.72	5,511.11	58,411.97	7,665.38	32,802.53	5,019.35	11,661.84	121,072.18	238,638.90
Maine	15,000	15,000	60,000	10,346.08	100,346.08	----------	45,775.61	800.00	----------	17,840.48	688.93	65,105.02	165,451.19
Maryland	15,000	15,000	60,000	14,275.24	104,275.24	19,319.68	42,981.25	16,554.23	----------	21,893.81	2,484.18	103,233.15	207,508.30
Massachusetts	15,000	15,000	60,000	9,091.10	99,091.10	----------	201,226.36	9,820.38	71,395.29	7,634.91	----------	290,076.94	389,168.04
Michigan	15,000	15,000	60,000	33,483.92	123,483.92	----------	242,589.09	----------	----------	26,087.04	----------	268,676.13	392,160.05
Minnesota	15,000	15,000	60,000	28,398.82	118,398.82	----------	358,363.78	7,554.00	883.75	54,286.95	----------	421,088.48	539,487.30
Mississippi	15,000	15,000	60,000	36,325.70	126,325.70	23,100.32	133,276.00	1,000.00	7,855.09	66,212.70	----------	231,444.11	357,769.81
Missouri	15,000	15,000	60,000	38,483.90	128,483.90	32,361.02	32,721.83	24,346.31	37,321.94	41,220.42	----------	167,971.52	296,455.42
Montana	15,000	15,000	60,000	7,751.58	97,751.58	25,093.47	74,610.66	----------	----------	50,070.76	----------	149,774.89	247,526.47
Nebraska	15,000	15,000	60,000	19,388.30	109,388.30	----------	140,182.37	----------	----------	62,062.82	----------	202,245.19	311,633.49
Nevada	15,000	15,000	60,000	1,230.32	91,230.32	1,083.02	914.71	----------	----------	8,021.78	----------	10,019.51	101,249.83
New Hampshire	15,000	15,000	60,000	4,178.60	94,178.60	13,004.81	1,494.90	----------	----------	3,631.98	33,459.39	51,591.08	145,769.68
New Jersey:													
College	15,000	15,000	60,000	15,262.92	105,262.92	----------	----------	----------	----------	----------	----------	----------	105,262.92
State	----------	----------	----------	----------	----------	----------	459,982.25	----------	----------	----------	----------	459,982.25	459,982.25
New Mexico	15,000	15,000	60,000	6,880.50	96,880.50	32,570.77	6,000.00	----------	----------	17,201.27	----------	55,772.04	152,652.54

New York:													
Cornell	13,500	13,500	54,000	40,424.24	121,424.24		571,818.75		23,942.04	47,884.10	2,434.45	646,079.34	767,503.58
State [2]	1,500	1,500	6,000	4,491.58	13,491.58	744.20	363,970.28			14,821.91		379,536.39	393,027.97
North Carolina	15,000	15,000	60,000	51,314.00	141,314.00	2,887.12	123,451.94	3,196.94		17,328.27	1,781.90	148,646.17	239,960.17
North Dakota [2]	15,000	15,000	60,000	12,337.88	102,337.88	47,482.96			230.00	36,970.71	64.84	84,748.51	187,086.39
Ohio	15,000	15,000	60,000	46,507.38	136,507.38	356,871.89	183,890.00			114,195.95	7,711.34	662,669.18	799,176.56
Oklahoma	15,000	15,000	60,000	34,225.42	124,225.42	19,094.43	54,527.04		59,197.21	28,821.12		161,639.80	285,865.22
Oregon	15,000	15,000	60,000	10,087.90	100,087.90	56,922.95	266,669.92	7,959.30	37,680.43	54,553.56		423,786.16	523,874.06
Pennsylvania	15,000	15,000	60,000	67,344.76	157,344.76	2,154.08	103,878.63			46,802.04	19,375.57	172,210.32	329,555.08
Puerto Rico [2]	15,000	15,000	5,000	24,276.08	59,276.08		136,447.44					136,447.44	195,723.52
Rhode Island [2]	15,000	15,000	60,000	1,131.92	91,131.92	1,554.95				8,261.46		9,816.41	100,948.33
South Carolina	15,000	15,000	60,000	29,732.48	119,732.48	15,497.06	73,000.00			94,847.17		183,344.23	303,076.71
South Dakota	15,000	15,000	60,000	12,216.22	102,216.22	15,268.59	16,560.00	1,901.39	10,811.05	11,414.69		55,955.72	158,171.94
Tennessee	15,000	15,000	60,000	37,391.94	127,391.94		30,655.54		31,152.23			61,807.77	189,199.71
Texas	15,000	15,000	60,000	74,682.38	164,682.38	77,310.90	279,605.00			128,499.79	103,687.89	589,103.58	753,785.96
Utah	15,000	15,000	60,000	5,251.84	95,251.84	5,467.37	28,500.00	1,500.00		18,661.70	2,922.23	57,051.30	152,303.14
Vermont	15,000	15,000	60,000	5,235.80	95,235.80	784.74			24,597.88	548.60		25,931.22	121,167.02
Virginia	15,000	15,000	60,000	35,572.28	125,572.28		89,250.00			8,568.95		97,818.95	223,391.23
Washington	15,000	15,000	60,000	14,757.86	104,757.86		48,742.48	1,933.58		37,273.69	37,273.70	125,223.45	229,981.31
West Virginia [2]	15,000	15,000	60,000	26,906.72	116,906.72	15,015.46	36,308.40	1,050.00		59,734.02	2,000.00	114,107.88	231,014.60
Wisconsin	15,000	15,000	60,000	30,112.44	120,112.44		297,003.00	69,585.00		47,598.00		414,186.00	534,298.44
Wyoming	15,000	15,000	60,000	3,379.76	93,379.76	44,819.29	55,482.68			27,081.67		127,383.64	220,763.40
Total	765,000	750,000	2,905,000	1,200,000.00	5,620,000.00	1,402,871.21	7,445,105.33	366,761.07	764,168.13	1,738,145.30	357,201.68	12,074,252.72	17,694,252.72

[1] Hawaii also received $12,066 through appropriations to the U. S. Department of Agriculture.

[2] Including unexpended balances—Illinois, Hatch $1,032.12, Bankhead-Jones $308.78; Indiana, Bankhead-Jones $2,237.47; New York State, Purnell $95.82, Bankhead-Jones $0.12; North Dakota, Purnell $5.86, Bankhead-Jones $0.01; Puerto Rico, Hatch $127.43, Adams $2,086.34, Bankhead-Jones $3,119.90; Rhode Island, Hatch $0.35, Adams $96.70, Purnell $25.25; West Virginia, Adams $0.03.

TABLE 6.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$15,000	$11,390.34	$1,222.69	$6.04	$207.90	$199.78	$110.05	$35.19	$274.03
Alaska	15,000	5,869.01	4,845.35	434.80	160.66	550.61	1,020.23	9.60	491.24
Arizona	15,000	14,998.15			1.85				
Arkansas	15,000	8,266.28	2,038.12	896.42	361.32	15.34	192.26	388.11	772.69
California	15,000	15,000.00							
Colorado	15,000	14,954.25							
Connecticut:									
State	7,500	7,500.00							
Storrs	7,500	6,175.58	50.00	20.93	89.42	31.76	170.11		
Delaware	15,000	8,740.45	1,788.82	830.56	1,326.81	12.35	348.72	245.39	181.32
Florida	15,000	15,000.00							
Georgia	15,000	7,421.00	1,954.20	757.75	1,189.40	32.75	789.37	33.90	348.34
Hawaii	15,000	6,268.08	3,293.35	997.56	247.99	155.11		417.65	239.54
Idaho	15,000	9,808.33	2,806.21	46.45	83.05	61.65	24.56	315.53	37.74
Illinois	15,000	14,005.81	994.15						
Indiana	15,000	15,000.00							
Iowa	15,000	14,999.67			.33				
Kansas	15,000	9,700.00	4,279.48		65.30	7.09	3.50	55.50	16.19
Kentucky	15,000	14,218.18		300.00				105.24	5.85
Louisiana	15,000	8,502.28	3,952.83	1,005.55	28.21		24.04	9.10	113.40
Maine	15,000	8,450.03	1,775.73	118.18	871.78	107.56	746.77	172.03	126.56
Maryland	15,000	14,018.91	656.80		40.99		7.76		
Massachusetts	15,000	14,567.23			2.00				16.02
Michigan	15,000	15,000.00							
Minnesota	15,000	14,182.98	44.81	3.99				284.28	115.31
Mississippi	15,000	7,276.53	2,547.41		882.35	73.15	439.94	9.95	425.28
Missouri	15,000	5,461.74	4,544.16	1,304.45	204.39	71.32	22.87	151.78	284.45
Montana	15,000	7,043.29	1,961.80	2,260.34	766.24	34.23	2.21	28.49	375.69
Nebraska	15,000	15,000.00							
Nevada	15,000	7,215.00	1,358.20	437.18	846.78	193.01	256.90	23.50	244.57
New Hampshire	15,000	9,704.53	639.50	681.28	1,169.28	305.49	701.10	114.47	153.44
New Jersey	15,000	11,147.50	504.55	219.97	400.99	4.94	17.06	69.65	314.33
New Mexico	15,000	8,534.03	3,473.47	878.05	410.74	58.82	17.05	372.65	599.57
New York:									
Cornell	13,500	7,197.88	4,902.28		225.84			680.59	38.65
State	1,500	1,500.00							
North Carolina	15,000	11,788.00	465.85	460.52	520.03	65.21		93.51	231.51
North Dakota	15,000	12,172.61	2,266.77		3.75		485.53		
Ohio	15,000	7,415.25		301.62	26.51	17.23	1,431.85	1,109.74	695.75
Oklahoma	15,000	7,200.00	2,835.50	50.00	170.69	56.84	54.90	475.13	844.83
Oregon	15,000	8,367.37	4,583.32	788.37	173.00	38.78	18.69	354.17	102.58
Pennsylvania	15,000	12,493.00	1,083.41	1,162.53	65.00	10.65			137.00
Puerto Rico	15,000	9,428.42	2,558.05	713.57	225.91	.23		2.40	40.00
Rhode Island	15,000	9,089.60	2,532.36	166.46	151.37	26.63	288.89	223.23	345.12
South Carolina	15,000	9,256.00	1,886.29	573.00	538.12	25.03	37.33	163.60	111.72
South Dakota	15,000	8,557.40	1,492.57	2,660.34	217.02	52.31	7.65	265.49	368.76
Tennessee	15,000	9,182.00	3,390.89	618.54	570.82	25.45	10.00	30.32	167.58
Texas	15,000	13,588.80	112.25		104.07			99.64	
Utah	15,000	8,113.63	3,630.98	125.03	61.09	15.73	4.75	267.63	357.88
Vermont	15,000	8,089.33	1,920.10	1,569.82	247.86	9.82	936.09	63.07	118.45
Virginia	15,000	9,152.11	4,686.54		67.61	1.77	5.07	12.08	233.02
Washington	15,000	9,301.85	1,305.32	3,037.86	180.71	.32		74.20	228.43
West Virginia	15,000	5,323.36	3,952.29	1,155.23	235.28	83.61	117.01	948.24	812.54
Wisconsin	15,000	14,432.67	391.38						
Wyoming	15,000	6,118.00	4,350.72	556.94	1,312.38	9.09	491.89	40.69	189.98
Total	765,000	533,186.46	93,078.50	25,139.33	14,454.84	2,353.66	8,784.15	7,745.74	10,159.36

the Act of Mar. 2, 1887 (Hatch Act) for the year ended June 30, 1937

Expenditures—Continued											
Fertilizers	Feeds	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
$171.42		$407.14	$338.23	$419.52	$10.82		$145.99	$8.58	$52.28		
184.76	$319.37	5.63	207.67	258.93	53.00	$7.50	121.60	280.40	179.64		
135.16	1,252.05		276.40	218.00	51.55		121.30	15.00			
							45.75				
			798.67		163.53						
93.05		886.63	108.26	132.72	113.93		153.10	3.75	34.14		
50.50	173.12	76.93	423.48	309.38	44.29		1,129.34	65.53	200.72		
71.60	2,033.71	7.10	466.46		791.29			10.56			
9.60	12.78		35.25	14.36	135.25	18.00	944.31	10.00	636.93		
											$0.04
			44.26	65.38	273.47		489.83				
		25.00		83.15	15.00		247.58				
243.51			839.80	72.60	7.38		201.30				
33.02	48.85	467.76	55.66	112.55	240.68	25.00	1,498.50	22.09	106.25	$21.00	
55.56	53.46			66.00			100.52				
				70.50			344.25				
	3.47		24.60		120.27		220.29				
40.00	217.50	6.38	1,190.64	356.42	14.00		1,006.07	7.20	507.18		
1.50	2,048.58	160.82	329.95	169.19			239.30		5.50		
	1,101.14	459.82	315.50	103.45	153.55	75.00	307.76	11.49			
17.34	1,474.21	112.57	53.75	200.98	83.50	1,537.87	449.43	50.45	444.76		
34.49	9.75	694.48	76.83		23.15	4.00	688.21				
117.18	360.00	231.95	176.07	149.33	324.03		717.50	27.05	217.90		
37.93		28.64	111.15	92.67	190.05	50.00	73.41	71.77			
		17.50	87.43	19.08			330.75				
46.62		2.25	50.24	224.95	39.08		966.26	36.00	9.97		
							71.34				
149.92	1,123.28		2,313.88	164.18	207.19		43.60				
98.80	929.80		594.50	159.37	413.55	531.82	471.42	9.00	103.85		
			49.28	312.14	34.52		144.27	2.01	31.50		
			15.01				33.40				
		28.72	36.20	195.00	752.39		999.21				19.90
202.82	149.47	304.25	1,077.73	15.20	22.25		245.76	1.00	157.86		
168.61	358.09	728.16	252.86	168.15	150.00		524.07	27.00	31.97		
3.50	748.64	33.45	32.35	21.78	178.28	185.00	175.46				
48.56		365.39	135.91	13.25	45.98		383.17	.60	11.54		
		19.46	59.04	141.50	121.25	200.00	507.29	9.36	37.34		
	1,773.40	58.79	46.29	60.72	39.55	7.16	436.61	.76			
59.30	21.25	161.40	643.05	122.44			554.70	161.65	321.67		
237.70	10.20		46.11	11.65	5.91		522.64	1.69	5.90		
		111.85	48.82	28.60	32.00		650.04				
133.81	498.15	8.26	355.85	216.63	24.15	475.00	624.56	36.03			
							175.95				
	925.50		837.49		75.97		91.35				
2,446.26	15,645.77	5,410.33	12,554.67	4,769.77	4,950.81	3,116.35	17,197.19	868.97	3,096.90	21.00	19.94

TABLE 7.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures						
		Salaries	Labor	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$15,000	$11,932.54	$1,397.23	$18.88	$155.04	$123.60	$523.49	$268.46
Arizona	15,000	9,920.16	2,143.78	49.64	23.82		164.69	572.11
Arkansas	15,000	9,748.00	1,940.47	78.13	70.83	222.90	1,249.91	376.08
California	15,000	13,325.52	1,674.48					
Colorado	15,000	15,000.00						
Connecticut:								
State	7,500	7,500.00						
Storrs	7,500	6,748.00		1.02	.84			94.50
Delaware	15,000	10,749.67	1,831.44		15.82		1,628.54	22.82
Florida	15,000	15,000.00						
Georgia	15,000	10,455.16	1,493.15	5.98	169.51	692.35	389.39	28.90
Hawaii	15,000	9,528.80	4,079.45	2.36	5.01		290.37	18.74
Idaho	15,000	13,817.86	395.77	5.40	10.09	215.85	235.87	23.49
Illinois	15,000	11,272.42	3,727.33					
Indiana	15,000	12,622.00	711.41	11.83	8.87		388.54	1.93
Iowa	15,000	14,604.05	60.74					
Kansas	15,000	10,300.00	3,193.58	4.70	1.50		570.94	8.74
Kentucky	15,000	14,814.31	33.00			24.03	84.06	3.70
Louisiana	15,000	9,981.62	2,128.01	6.45	27.03		567.24	166.00
Maine	15,000	11,550.05	1,477.04	3.41	10.72	32.19	24.88	84.61
Maryland	15,000	12,716.36	986.60	15.49		34.39	262.48	318.27
Massachusetts	15,000	15,000.00						
Michigan	15,000	15,000.00						
Minnesota	15,000	14,651.72	231.70					
Mississippi	15,000	9,458.83	3,737.23	10.50	12.86	556.27	181.64	209.59
Missouri	15,000	3,481.72	4,842.63	49.70	60.79	12.50	1,221.69	227.12
Montana	15,000	10,679.63	2,145.20	1.57	10.41		324.26	201.37
Nebraska	15,000	15,000.00						
Nevada	15,000	10,812.00	3,263.31	92.48	42.21		257.86	64.01
New Hampshire	15,000	12,419.50	582.18	18.06	62.49		452.69	96.77
New Jersey	15,000	10,670.00	51.73	9.15		529.67	1,042.93	106.76
New Mexico	15,000	9,179.16	3,178.19	104.29	94.27	279.77	1,186.73	143.83
New York:								
Cornell	13,500	13,088.09	284.61	8.19			103.85	15.26
State	1,500	1,500.00						
North Carolina	15,000	11,690.66	635.86	7.65	19.46	15.32	680.86	191.11
North Dakota	15,000	14,040.00	495.43				40.55	
Ohio	15,000	13,246.25					133.89	79.77
Oklahoma	15,000	8,085.16	1,431.42	2.35	94.93		1,085.25	279.61
Oregon	15,000	11,098.95	1,921.98	38.65	14.57		857.73	78.10
Pennsylvania	15,000	14,820.00	180.00					
Puerto Rico	15,000	6,916.65	2,038.69	52.55	103.57		56.06	478.59
Rhode Island	15,000	11,499.90	1,947.77	3.00	8.00	123.52	80.37	
South Carolina	15,000	9,605.50	2,701.05	165.22	17.11	281.61	391.68	133.55
South Dakota	15,000	8,292.42	4,343.56	23.33	42.38		208.58	213.04
Tennessee	15,000	12,128.50	1,129.34	11.50	28.07	52.64	495.16	107.33
Texas	15,000	15,000.00						
Utah	15,000	8,525.04	3,572.87	40.35	45.66		869.50	162.06
Vermont	15,000	9,825.84	3,603.97	36.02	17.27	78.61	387.44	192.20
Virginia	15,000	10,316.01	2,644.46	6.29	12.12		95.91	122.06
Washington	15,000	12,572.55	1,222.89	24.55		70.53	327.65	180.97
West Virginia	15,000	10,889.77	2,000.00	6.35	1.13	6.77	413.12	297.08
Wisconsin	15,000	11,592.97	3,239.00				100.00	
Wyoming	15,000	11,942.00	915.81	.24	6.18		487.01	33.12
Total	750,000	584,615.34	79,614.36	915.28	1,192.56	3,352.52	17,862.81	5,601.65

the act of Mar. 16, 1906 (Adams Act) for the year ended June 30, 1937

Expenditures—Continued											
Fertilizers	Feeds	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
			$76.21	$79.91	$321.84		$88.00		$14.80		
$22.95		$13.45	28.84	242.64	587.94		1,224.16	$5.82			
53.60	$210.25		18.72	22.00	728.24		221.00		52.37	$7.50	
	258.03				397.61						
		14.92	1.80		633.89		94.10	7.00			
	1,223.11	1.75	27.28	15.90	243.87		47.60		206.05		
89.12	175.50	15.75			477.35		308.30	9.25			
			2.20	20.96	129.66		99.89	37.10	5.86		
											$0.25
13.97	104.20		224.69		774.26	$138.30					
					335.21						
	673.40		7.98		158.12	16.04	65.00				
	20.20	5.70			15.00						
21.24	515.25		82.60		953.57	50.70	453.06		47.23		
		147.24	691.86		365.86				612.14		
					578.07		88.34				
							116.58				
592.10			121.99		83.06	1.63	31.05		3.25		
3.40	3,858.60	5.00	284.02	106.97	596.64	82.75	44.38	11.98	110.11		
		32.16	3.72	53.38	858.25		690.05				
	244.98		12.39	35.00	12.50	24.01	139.25				
	486.87		38.68		538.61	50.00	188.66		65.49		
55.59		146.20	50.23	738.55	1,146.68		113.30	54.90	284.31		
23.04		33.44	314.14	25.00	165.02		46.48	171.74	54.90		
11.83	6.62		425.71		362.98	94.46	833.73		23.75		
	161.55	25.00				150.00			87.47		
	1,353.28		21.89	11.09	6.50	36.00	6.18		105.15		
	1,904.93	11.13	179.48	23.74	1,255.38	85.00			561.62		
17.00			24.05	95.25	493.70		359.89	.13			
194.76			32.47	2.00	436.59		3,186.26				1,501.81
	1,194.01				143.00						.43
43.72	90.00	113.18	211.83	92.00	655.01		414.07		57.81	26.66	
	296.10	154.34	73.40	10.00	479.45		825.40		38.00		
25.92		47.94	30.12	59.48	690.07		170.69		23.24		
		23.48	116.62	118.97	1,120.38	6.00	390.18	8.89			
26.93		8.69	38.98	31.63	570.80		99.50	1.40	80.72		
11.19	1,424.86		29.39	19.93	62.58		226.35	13.95	4.90	10.00	
3.45		99.00	11.00	51.25	164.52		254.94		16.70		
	58.75		37.53		1,285.43		4.07				
							68.03				
	234.87	4.00	64.27	22.04	228.23	146.50	708.39	9.10	198.24		
1,209.81	14,495.36	902.37	3,284.09	1,877.69	18,055.87	881.39	11,606.88	331.26	2,654.11	44.16	1,502.49

TABLE 8.—*Expenditures from Federal appropriations received under*

Station	Amount of appropriation	Expenditures							
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$60,000	$35,948.50	$9,080.45	$1,362.70	$289.60	$222.22	$970.90	$948.58	$864.65
Arizona	60,000	37,380.95	6,286.36	2,556.52	168.13	177.64	593.51	2,416.96	1,515.05
Arkansas	60,000	47,867.67	2,428.27	2,697.53	829.42	12.95	381.87	462.65	245.82
California	60,000	60,000.00							
Colorado	60,000	46,304.93	7,101.79	22.12	667.43	54.44	340.25	803.75	149.03
Connecticut:									
State	30,000	24,091.78	2,078.40		218.98	17.63	881.72	479.81	493.24
Storrs	30,000	22,973.77	3,557.03	9.39	684.79	8.08		827.68	11.20
Delaware	60,000	39,663.95	6,893.36	1,199.97	10.80	44.41	623.72	675.08	368.38
Florida	60,000	43,708.00	9,918.86		107.11		55.57	1,516.51	717.63
Georgia	60,000	27,333.57	14,210.97	752.46	347.52	466.34	2,915.19	1,807.63	898.06
Hawaii	20,000	11,776.06	3,207.07		38.65	16.04		1,787.73	247.24
Idaho	38,328.26	7,584.55	1,722.16	586.61	212.57	424.32	2,654.50	185.95	
Illinois	60,000	39,671.59	8,232.50	1,948.90	1,435.39	55.39		1,270.04	5.34
Indiana	60,000	44,243.09	5,594.04	1,257.96	356.48	69.61		1,332.72	89.19
Iowa	60,000	59,463.74							
Kansas	60,000	37,500.00	17,791.76	21.52	291.33	2.96	11.22	1,442.82	231.91
Kentucky	60,000	53,071.40	1,833.66	1,400.35	113.72	14.60	21.48	1,020.64	174.88
Louisiana	60,000	42,209.52	11,108.23	451.21	286.13	139.47	33.85	659.06	613.94
Maine	60,000	37,444.04	9,697.67	23.25	314.99	154.82	858.59	992.48	996.33
Maryland	60,000	46,139.49	3,811.01	1,479.59	343.39	.50		1,484.52	585.78
Massachusetts	60,000	52,571.35	2,606.29	477.18	141.01		6.50	862.78	165.70
Michigan	60,000	43,404.32	8,275.45	1,614.98	507.55	14.51		697.81	203.86
Minnesota	60,000	47,949.88	2,593.54	89.26	42.68	251.15		1,530.83	510.79
Mississippi	60,000	36,550.93	12,194.43	7.30	488.78	236.12	1,437.14	996.30	1,066.73
Missouri	60,000	20,091.78	15,362.03	2,638.09	402.98	474.43	267.18	3,697.13	1,811.67
Montana	60,000	32,898.32	16,785.81	2,760.52	591.76	143.01	193.52	1,109.00	921.37
Nebraska	60,000	36,631.47	11,757.93	1,831.82	56.86	251.65	11.53	1,307.69	233.86
Nevada	60,000	32,935.89	10,906.41	380.51	959.60	75.60	347.49	279.63	1,309.91
New Hampshire	60,000	42,732.07	8,739.09	981.06	351.13	139.44	70.99	780.22	618.10
New Jersey	60,000	50,286.01	1,921.14	209.29	413.23		21.75	1,973.43	487.06
New Mexico	60,000	30,507.55	12,454.09	1,113.22	1,107.54	272.36	760.40	1,032.51	440.96
New York:									
Cornell	54,000	47,625.02	294.47		245.81	26.11		517.36	22.28
State	6,000	5,850.00	54.16		.10			50.00	
North Carolina	60,000	35,652.50	9,025.59	2,233.32	765.64	117.56	33.96	446.17	261.70
North Dakota	60,000	37,814.33	4,129.39		39.71		38.50	646.11	610.08
Ohio	60,000	49,422.07	445.87	207.35	29.79		440.48	225.52	96.24
Oklahoma	60,000	26,819.97	15,120.72	1,120.79	492.67	30.60		1,445.41	1,074.82
Oregon	60,000	33,660.35	14,081.45	1,794.46	1,883.75	184.24	75.57	1,037.29	312.01
Pennsylvania	60,000	43,535.22	5,047.22	625.99	278.97	147.50	117.55	1,703.68	412.85
Puerto Rico	5,000	3,499.99	513.56		66.69				
Rhode Island	60,000	37,826.16	11,854.08	1,084.23	57.15	31.85	461.91	1,074.45	352.36
South Carolina	60,000	39,019.37	11,277.99	1,346.05	794.99	26.68	72.07	898.03	158.83
South Dakota	60,000	28,941.53	12,413.93	4,220.11	917.42	182.35	55.67	1,049.09	410.57
Tennessee	60,000	43,644.29	8,711.91	331.32	329.87	285.22	213.21	1,193.31	470.57
Texas	60,000	40,646.93	13,209.24		678.67	65.07	57.34	1,393.62	232.91
Utah	60,000	36,738.16	13,881.65	1,525.98	647.08	67.74		856.14	892.02
Vermont	60,000	36,275.62	10,656.64	2,082.87	905.63	155.55	1,809.94	944.82	659.16
Virginia	60,000	38,727.70	13,208.19	485.07	632.10	40.25	135.35	338.86	587.25
Washington	60,000	40,732.77	9,474.41	1,603.18	223.44	11.88		1,526.11	646.41
West Virginia	60,000	41,302.56	7,707.44	1,112.13	105.24	16.77	379.55	1,199.50	655.87
Wisconsin	60,000	46,739.43	12,741.49		3.20			304.92	
Wyoming	60,000	40,674.59	3,863.28	909.36	115.71	344.77		1,099.33	289.86
Total	2,905,000	1,976,828.44	411,724.87	49,691.07	21,367.22	5,262.08	15,119.79	54,800.21	24,309.42

the act of Feb. 24, 1925 (Purnell Act) for the year ended June 30, 1937

Expenditures—Continued

Fertilizers	Feeds	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
$169.07	$2,311.83	$138.83	$824.94	$2,056.04	$2,686.76	$14.13	$527.63	$36.24	$1,546.93		
491.28	1,495.29	5.00	257.26	2,277.68	2,044.96		2,032.63	72.33	228.45		
25.00	75.94	158.50	590.20	43.95	1,499.73		2,177.72	55.00	437.78	$10.00	
54.75	250.65	161.38	372.67	114.53	1,535.71		1,828.18	6.56	231.83		
178.59			313.36	105.06	76.54		343.53	127.25	594.11		
	44.80	146.14		298.44	627.37	20.10	714.31	76.90			
271.31	3,647.14	148.21	368.54	390.67	1,774.01		3,202.68	184.42	313.35	220.00	
	699.74	11.66	174.52	539.31	580.37	271.97	1,663.69	25.24	9.82		
245.54	3,164.31	229.86	2,354.52	564.74	1,946.58	350.00	1,296.92	28.39	1,087.40		
24.50		31.78	7.90		2,550.23		260.55	52.25			
12.61	1,890.02	74.04	207.83	786.58	2,688.16	100.00	2,013.54	37.85	119.49	370.96	
	59.27	30.99	1,146.33	387.84	2,412.31		3,251.21	89.90	3.00		
	97.82		223.46	278.90	448.95		5,915.32	40.71	51.75		
					536.26						
	716.73	10.00	350.22	71.67	851.41	556.55	108.16	29.04	9.70	3.00	
	116.00	11.30	1.39		618.75	8.50	1,593.33				
303.53	1,556.06	13.42	204.50	186.80	478.25	99.50	1,484.50	161.04	10.99		
1,785.06	1,503.10	87.54	976.54	385.37	1,167.76	248.15	2,969.29	180.52	82.75	131.75	
382.05	583.61	4.50	928.41	132.68	751.22	550.10	2,781.36	8.70	33.09		
	663.31	154.14	7.86	34.94	982.76	101.30	1,217.70	7.18			
26.10	533.86	32.15	227.81	148.43	498.19	1.00	3,753.98		60.00		
	2,358.54	13.24	83.76	265.73	2,739.26	445.06	798.56	133.74	193.98		
855.82	1,740.65	60.58	1,537.68	841.52	792.82	40.00	747.80	19.54	385.86		
33.53	6,446.39	7.76	2,611.16	381.48	2,268.99	1,914.11	1,324.22	158.96	108.11		
54.55	402.91	41.19	730.36	628.02	312.23		2,147.43			280.00	
	3,245.22	85.30	47.63	238.05	3,661.27	183.95	398.00	4.05	53.72		
	2,681.30	97.70	1,619.08	1,310.57	178.53	401.65	2,966.22	138.55	3,411.36		
11.06	748.66	.50	342.44	160.64	822.97	9.45	3,047.07	22.75	30.36	392.00	
19.19	117.65	53.83	764.39	455.00	1,449.27	8.50	1,546.26	230.64	43.36		
272.37	3,926.69	52.99	1,407.05	656.31	848.60	1,574.15	2,670.40	371.60	251.21	280.00	
	9.22	25.00	220.62		3,391.64		1,582.62	4.85	35.00		
							45.72				$0.02
114.87	5,968.45	3.35	275.56	350.27	1,284.63		3,449.34	1.44	15.65		
	11,881.64	35.77	441.86	25.83	774.42	2,990.03	287.64	16.00	268.69		
	5,314.94	2.57	833.78		309.10	2,093.02	579.27				
25.00	7,105.17	10.10	924.19	609.27	3,269.57	479.20	738.84	125.00	608.68		
16.90	681.83	65.30	183.92	1,595.01	339.58		3,432.68	41.12	614.54		
.53	1,980.25		1,279.46	88.75	2,815.03	299.90	1,662.30	4.80			
							702.00				217.76
395.62	3,449.61	71.96	1,361.35	322.55	539.77		971.11		145.47		.37
335.36	1,696.58	224.02	416.62	1,171.01	1,340.76		1,133.37	7.40	80.87		
	2,770.80	349.55	677.09	1,661.07	4,203.96		1,852.85	.96	293.05		
177.57	394.15	297.59	656.44	390.82	827.48		1,104.39	37.94	813.92	120.00	
	592.54	55.52	61.93	138.76	1,513.95	80.00	841.69	14.25	397.58	20.00	
48.71	12.83	86.56	834.81	670.50	776.92		2,451.76	38.93	63.96	406.25	
17.47	510.60	29.53	275.05	398.73	1,786.11	116.00	1,611.22	304.62	1,460.44		
	47.50	36.91	577.19	261.09	2,001.36	8.00	2,723.57	22.00	167.61		
174.56	1,683.76	148.10	283.90	58.55	833.91	707.25	1,816.17		75.60		
717.75	1,815.29	11.38	1,246.14	165.84	1,009.77	575.19	1,296.15	183.43		500.00	
							210.96				
	8,483.86	119.03	206.77	321.19	1,046.47	308.95	2,000.81	6.40	23.61	186.01	
7,240.25	95,476.51	3,434.77	29,438.49	21,970.19	67,894.65	14,555.71	85,276.65	3,108.49	14,363.07	2,919.97	218.15

TABLE 9.—*Expenditures from Federal appropriations received under the act of*

Station	Expenditures								
	Amount of appropriation	Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, water, light, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama	$41,347.56	$23,503.85	$4,453.66		$134.01	$645.95	$225.30	$1,395.51	$929.22
Alaska	1,118.24	165.61	368.64	$54.35		36.79		35.26	187.55
Arizona	6,211.28	1,794.80	1,009.85		123.54	.87		57.19	274.36
Arkansas	31,991.60	27,045.16	131.80		342.66	66.08	44.01	614.71	252.91
California	32,970.98	32,969.98			1.00				
Colorado	11,215.48	3,688.03	4,879.23		207.42	63.95		74.79	27.60
Connecticut:									
State	5,164.52	4,021.72	270.00	7.50	53.66	.52	405.47	269.99	33.38
Storrs	5,164.52	3,215.69	768.60	3.25	20.52	3.34		98.42	91.48
Delaware	2,505.10	2,000.00	2.58			2.97		197.25	.38
Florida	15,400.82	1,362.90	5,362.99		3.95	2.91	233.40	48.50	388.96
Georgia	43,761.46	20,975.39	4,792.99		187.22	162.39	1,717.19	814.15	706.56
Hawaii	4,593.20	2,685.00	754.82		.70	7.85		219.63	79.02
Idaho	6,859.28	2,033.34	2,052.65		62.49	40.96		106.49	69.99
Illinois	43,368.26	17,865.32	8,250.32		192.13	456.99		6,061.35	354.41
Indiana	31,361.30	10,216.70	4,290.86	15.00	61.77	125.42		2,445.55	59.10
Iowa	32,427.32	31,226.67							
Kansas	25,025.48	12,800.00	3,436.81	283.75	35.53		3.15	505.49	186.05
Kentucky	39,469.02	25,547.28	2,408.71			13.95		684.13	127.64
Louisiana	27,566.72	20,702.14	2,793.03		121.79	96.50		436.29	293.27
Maine	10,346.08	4,757.62	2,705.18		77.22	27.21	63.10	199.66	227.36
Maryland	14,275.24	10,518.20	904.58	361.25	11.69			485.43	224.10
Massachusetts	9,091.10	9,091.10							
Michigan	33,483.92	23,853.36	4,572.87	44.40	14.62	69.51		877.47	521.76
Minnesota	28,398.82	16,653.95	2,569.74	15.62	62.42	126.81		1,160.02	943.71
Mississippi	36,325.70	17,114.13	6,678.40	33.01	289.08	309.70	714.03	711.27	1,143.66
Missouri	38,483.90	12,793.33	7,651.52	801.12	268.89	397.91	972.86	3,399.73	706.03
Montana	7,751.58	4,917.02	2,233.00		26.07			8.00	43.61
Nebraska	19,388.30	16,997.65	1,344.34		.27			88.30	
Nevada	1,230.32	905.00			27.62				
New Hampshire	4,178.60	2,980.67	697.42		25.45	18.59	.66	29.30	61.38
New Jersey	15,262.92	7,240.00	638.49	6.50	115.48	2.59	1,126.17	1,111.58	434.87
New Mexico	6,880.50	3,273.30	882.95		165.79	22.78	167.37	263.94	145.16
New York:									
Cornell	40,424.24	29,987.19	1,164.57		43.87	159.28	47.98	1,262.50	275.51
State	4,491.58	3,150.00	351.00		.60			814.01	
North Carolina	51,314.00	38,878.00	4,269.97	39.60	96.66	158.54	243.57	780.40	721.79
North Dakota	12,337.88	11,417.69	675.63		5.66	14.40		24.11	20.30
Ohio	46,507.38	39,341.88	87.20		2.73	69.20		143.70	176.36
Oklahoma	34,225.42	11,190.71	7,959.69	422.58	99.02	5.26	62.23	957.43	697.58
Oregon	10,087.90	7,927.75	856.09		101.68	6.70	46.70	48.60	94.28
Pennsylvania	67,344.76	38,490.09	5,748.10	574.36		152.59	103.91	1,158.41	734.14
Puerto Rico	24,276.08	10,741.64	5,779.46		35.15	39.04		988.31	497.01
Rhode Island	1,131.92	801.92							
South Carolina	29,732.48	14,431.50	3,665.75		240.50	61.04	383.05	719.26	638.56
South Dakota	12,216.22	3,678.50	3,935.08		31.21	73.94	86.99	158.06	289.61
Tennessee	37,391.94	14,745.39	8,546.38		277.29	330.25	362.36	115.50	1,997.51
Texas	74,682.38	38,868.08	13,253.76		242.29	194.45	67.73	2,088.49	243.41
Utah	5,251.84	1,479.96	2,235.80		65.61	5.36		60.08	65.06
Vermont	5,235.80	4,970.99	117.67						
Virginia	35,572.28	17,524.78	6,123.15		41.73	92.53	180.84	1,048.18	873.21
Washington	14,757.86	9,546.62	2,429.91	3.97	70.11			437.29	115.20
West Virginia	26,906.72	14,818.24	5,529.38	466.33	107.13	15.69	128.51	1,433.11	570.60
Wisconsin	30,112.44	25,044.38	3,599.81					209.93	
Wyoming	3,379.76	2,816.50	29.40		2.00	2.62		15.26	
Total	1,200,000.00	715,766.72	153,263.83	3,132.59	4,096.23	4,083.43	7,386.58	34,862.03	16,523.65

June 29, 1935 (Bankhead-Jones Act), for the year ended June 30, 1937

Expenditures—Continued

Fertilizers	Feeds	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance
$82.96	$2,362.24	$25.82	$166.71	$434.83	$1,678.88	$828.96	$1,403.33	$33.79	$3,042.54		
16.80			198.83		48.41			6.00			
	44.99		1,327.11	920.31			658.26				
	14.91		360.02	225.88	1,348.78	118.57	1,343.24	26.98	55.89		
		12.12	542.82	30.08	583.66		1,077.03		28.75		
			35.50		19.78		47.00				
182.39		56.31			247.62		476.90				
		16.67			254.05		31.20				
80.85			870.84	133.73	19.23	507.00	198.20	124.50	2,762.86	$3,300.00	
108.04	1,566.95	216.47	2,435.86	394.38	1,564.25	1,349.98	1,667.03		4,552.61	550.00	
22.50		15.17			683.51		125.00				
	948.00	6.40	33.92		148.82		741.22		340.00	275.00	
	292.63		1,263.79	229.17	5,948.93		2,021.38	1.00	421.37		$9.47
6.61	639.49		9.70	88.11	11,043.79		1,548.03		811.17		
			1,028.05		172.60						
	1,674.53	5.00	347.84	7.30	1,313.69	497.00	157.49	6.75	3,762.10	3.00	
			74.54	493.58	1,380.64		647.63		8,090.92		
6.39	388.43		201.72	436.18	1,142.54	200.00	745.68	2.76			
99.01	745.97	8.05	154.94	178.49	17.03	455.00	563.54	33.35	33.35		
45.19		12.45	22.84	76.60	552.39		879.16	6.00	140.36	35.00	
147.60	134.10		298.85		1,639.24		467.08	2.40	840.66		
21.39	673.81		853.79	211.47	783.97	1,182.50	1,078.30	29.06	232.26	1,800.00	
32.03	1,552.35	39.93	1,480.47	390.52	1,390.97	1,848.94	931.67	22.24	1,105.77	537.53	
9.36	2,178.51	19.24	568.68	423.24	2,214.96	175.50	2,596.66	1,029.01	2,277.35		
40.33	251.95		51.80		58.98		116.39	4.43			
					747.50		210.24				
				70.50			227.20				
		10.00	35.25	3.67	111.37		204.84				
	504.01	191.24	1,468.29	281.21	1,170.73	50.00	471.92	47.50	402.34		
		18.41	394.09	87.65	671.11		139.36		565.66	82.93	
21.47	575.02	76.43	270.56	109.76	1,769.76		2,221.53	3.00	2,435.81		
							175.97				
234.94		10.00	490.03	41.50	1,486.32	64.02	3,592.78	2.09	175.67	28.12	
		1.75	3.50	4.75			157.49		12.60		
	381.39	12.35	135.40	337.75	374.18	4,674.82	286.84		103.58	380.00	
87.19	2,495.40		1,567.94	327.16	3,367.53		200.39	10.00	4,775.31		
		2.23	27.65	324.00	241.35		210.87		200.00		
735.19	1,703.46		2,265.13	1,319.80	2,720.91		1,963.91	221.42	9,453.34		
138.63	170.17	32.38	141.74	56.50	1,365.04	57.00	2,189.70		297.55		1,746.76
					330.00						
325.21	492.68	49.70	855.07	48.92	1,326.69		1,037.29	57.14	5,331.12	69.00	
	2,292.58		61.19	210.18	282.35	225.00	469.09		422.44		
556.76	662.42	2.00	1,176.19	300.41	65.61	10.00	681.24	18.50	7,544.13		
13.75	7,116.84	243.98	323.26	334.48	5,146.51		4,177.19	8.00	2,360.16		
			26.20	159.61	26.88		1,127.28				
	20.00		8.64						118.50		
330.73	211.16	16.18	584.89	265.90	3,788.98		1,004.40		3,424.57	61.05	
	177.22	4.15	415.32	82.85	66.65	537.00	433.87		437.70		
170.80	479.27		212.67	15.67	283.96	46.30	1,394.55	.97	233.54	1,000.00	
14.57							243.75				
		5.02	38.30	114.02	180.02		176.62				
3,530.69	30,750.48	1,109.45	22,829.93	9,170.16	59,780.17	12,827.59	42,519.74	1,696.89	66,791.98	8,121.63	1,756.23

TABLE 10.—*Expenditures from supplementary funds received from within the States for the year ended June 30, 1937*

Station	Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, water, light, and power	Chemical supplies	Seeds, plants, and sundry supplies	Fertilizers	Feeds
Alabama	$50,517.24	$36,810.49	$1,969.74	$2,963.99	$1,966.49	$4,267.82	$459.45	$7,988.02	$6,428.53	$12,076.25
Alaska	2,278.80	2,475.53	672.12	117.24	417.54	187.70	78.11	444.30	72.40	
Arizona	48,050.25	15,828.47	3,623.02	2,111.22	72.65	1,739.79	1,612.34	3,115.56	603.32	15,941.90
Arkansas	31,832.33	18,608.04		2,026.73	287.97	4,473.62	6,097.79	397.43	1,157.19	4,951.93
California	383,658.48	153,463.40	19,182.92	17,264.63	5,754.88	20,142.07	18,223.78	34,529.26	6,714.02	43,161.58
Colorado	62,635.25	27,132.98	2,470.24	2,634.46	1,793.12	7,090.81	3,037.33	3,496.01	205.09	7,605.23
Connecticut:										
State	142,897.78	56,333.93	907.32	2,712.69	111.63	7,275.83	3,455.94	1,938.69	806.27	322.42
Storrs	25,974.62	9,010.68	312.19	1,301.23	870.09	477.28	2,483.38	1,016.72	208.44	2,730.24
Delaware	4,745.00	13,472.88		837.39	453.46	2,851.30	105.38	4,036.21	518.03	7,762.28
Florida	185,407.02	80,968.61	5,410.41	6,799.41	2,458.51	13,913.12	8,420.53	10,914.44	6,429.74	17,872.73
Georgia	5,470.26	5,865.69	13.56	306.51	800.16	4,384.53	228.78	4,865.50	384.05	120.45
Hawaii	16,075.94	6,211.51	720.00	1,417.14	276.27	1,587.81	1,822.43	3,312.85	662.46	4,141.23
Idaho	18,564.85	7,425.97	928.29	835.51	278.52	974.65	881.88	1,670.88	324.93	2,088.59
Illinois	223,193.65	81,658.71	9,480.06	7,260.64			13,473.15	25,529.95	4,962.37	31,911.19
Indiana	167,022.40	171,506.08	6,867.06	53,572.15	2,775.20	11,379.83	29,053.88	7,848.21	7,937.28	47,850.43
Iowa	131,624.14	34,420.99	18,014.55	4,787.24	1,321.44	1,379.72	3,190.16	18,840.18	470.10	17,696.17
Kansas	32,941.78	59,009.95	1,179.72	4,020.91	1,523.89	6,976.99	3,590.30	6,817.45	253.81	14,278.72
Kentucky	132,142.24	47,434.22	831.18	9,326.10	1,102.26	5,088.34	2,471.79	16,169.85	978.20	19,638.97
Louisiana	50,690.28	23,576.12	682.93	2,118.97	940.71	4,217.36	1,974.13	2,534.83	1,432.58	3,286.40
Maine	33,102.15	11,908.91	39.74	429.16	243.84	3,822.60	1,410.61	2,533.83	197.54	1,065.12
Maryland	29,354.88	25,728.63	752.22	1,121.27	1,681.41	1,937.07	1,009.23	4,858.04	1,483.52	11,065.42
Massachusetts	130,975.20	42,001.05	2,508.24	2,469.55	1,337.68	1,242.86	4,945.29	4,447.95	527.13	5,436.46
Michigan	119,884.22	63,286.72	15,085.58	1,910.93	522.90	3,099.11	5,742.57	8,589.36	1,696.95	12,379.20
Minnesota	206,215.42	82,486.18	2,163.01	7,605.87	1,326.18	19,585.35	16,052.06	8,805.65		23,439.54
Mississippi	44,418.42	37,936.85	1,547.11	2,643.05	1,430.41	4,756.13	216.36	17,684.40	1,546.26	5,819.04
Missouri	41,809.65	31,750.64	5,597.15	2,355.97	1,094.10	1,403.11	3,508.40	10,411.04	1,030.42	11,633.70
Montana	58,197.12	17,651.29	4,301.90	2,780.99	990.32	4,017.78	1,258.78	6,534.39	204.57	21,454.74
Nebraska	68,027.54	28,997.93	2,253.08	3,201.87	712.04	7,665.92	8,173.73	3,062.04	5,181.90	44,852.10
Nevada		59.00	246.14	103.96	27.02	66.84	6.14	218.55		
New Hampshire	16,032.33	3,722.34	224.98	767.32	84.62	98.56	2,139.17	1,129.79	497.62	198.72
New Jersey	315,049.89	14,391.78	6,081.92	11,081.58	836.05	15,294.90	10,046.62	1,162.22	1,367.35	31,452.79
New Mexico	7,726.35	3,682.69	497.31	385.11	209.74	644.29	142.27	573.45		4,020.72
New York:										
Cornell	410,292.56	68,078.04	15,027.20	8,333.91	1,288.06	24,497.77	15,439.02	16,854.36	3,370.87	11,894.91
State	166,631.39	31,499.83	6,487.38	4,418.21	474.84	11,999.66	3,675.07	7,509.80		5,035.96
North Carolina	43,697.37	36,966.48	139.40	1,831.82	673.19	3,783.93	243.68	6,302.73	3,463.98	8,293.51
North Dakota	13,736.40	7,448.19	965.45	1,087.19	13,689.94	17,956.25	1,385.89	1,607.46	9.96	8,563.52
Ohio	209,635.90	101,776.70	23,077.33	5,211.43	2,789.09	26,610.37	4,009.97	27,091.56	1,254.57	33,554.79
Oklahoma	63,698.14	12,484.57	1,300.13	2,068.58	872.45	356.92	734.81	11,036.04	16.25	9,841.82
Oregon	67,925.61	69,749.80	939.31	5,983.02	1,383.00	6,621.34	4,674.90	14,763.04	704.34	10,192.20
Pennsylvania	84,703.67	30,514.79	2,310.88	4,485.83	1,573.60		4,934.84	8,975.87	1,796.01	11,220.89

Puerto Rico	75,516.41	26,508.33	2,225.64	1,889.57	107.82	2,107.01	1,523.94	3,542.42	1,251.16	1,754.24
Rhode Island	534.55	3,633.41	28.61	693.15	73.67	627.82	126.92	432.12		19.41
South Carolina	28,601.00	40,849.09	276.19	1,072.99	1,258.63	4,421.68	3,054.06	13,603.05	6,947.26	15,096.45
South Dakota	9,661.00	6,010.72	760.00	222.27	165.69	267.72	444.66	1,089.26		10,743.65
Tennessee	16,938.00	13,398.57	493.89	839.73	775.61	1,157.23	138.20	1,861.01	295.09	8,021.55
Texas	240,318.50	81,214.47	8,753.11	10,023.01	1,505.47	7,598.57	6,766.16	32,461.40		26,614.79
Utah	14,730.13	16,638.95	1,085.85	2,318.06	196.42	491.01	523.83	2,380.47		1,607.69
Vermont	10,467.64	6,251.96	1,246.80	342.62	73.83	582.42	414.00	102.15	3.25	3,249.95
Virginia	56,975.28	16,265.38	2,017.87	1,337.56	452.48	999.08	1,100.50	1,945.27	667.03	2,560.84
Washington	34,590.57	42,897.17	978.43	1,127.49	822.87		2,958.25	12,808.61		6,801.58
West Virginia	33,748.84	17,704.30	339.31	1,027.94	94.41	3,525.39	463.98	11,061.06	849.41	20,476.94
Wisconsin	201,922.07	80,768.84	2,831.87	5,927.04		1,852.32	30,989.45	5,020.71	1,841.85	29,822.91
Wyoming	36,095.69			2,912.25	953.94		3,314.11	1,203.96	6,023.19	7,529.66
Total	4,606,936.20	1,925,477.85	185,848.34	222,424.46	62,926.11	277,499.58	242,228.00	407,129.40	82,776.29	659,151.52

Station	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance	Total
Alabama	$154.05	$4,249.77	$2,961.08	$710.36	$6,226.29	$9,097.00	$2,510.21	$7,682.92		$141,486.72	$300,526.42
Alaska	6.50	315.33	92.80	21.54	25.00			422.90		1,583.16	9,210.97
Arizona		2,924.40	3,953.07			3,163.05	720.36	1,393.20	$1,249.55	1,692.57	107,794.72
Arkansas	938.79	11,631.59	267.38	2,346.80	524.06	3,991.67	753.34	2,656.36			92,913.02
California	3,836.58	23,019.50	6,714.02	11,509.75	14,387.19	33,570.12	12,468.90	50,834.74	14,387.19	86,323.16	959,146.17
Colorado	341.13	7,689.55	1,696.45	3,003.40	4,176.12	5,089.99	320.13	12,466.88		25,798.99	178,683.16
Connecticut:											
State	2,132.04	5,783.23	1,600.47	1,142.07	107.75	11,070.88	2,388.49	5,965.24			246,952.67
Storrs	952.77	417.92	411.86	1,376.12	261.15	915.50	212.85				48,933.04
Delaware	367.40	1,019.37	34.75		321.77	316.43	312.26	2,069.11		3,541.88	42,764.90
Florida	2,748.63	27,539.97	5,729.58	10,338.61	4,362.86	16,310.09	2,648.43	45,391.63		19,354.95	473,019.27
Georgia	822.54	1,216.21	972.68	5.03	1,453.37	1,735.76	8,058.82	7,823.14	8,600.00	2,953.96	56,081.05
Hawaii	245.29	1,226.57	392.56	637.79	785.13	1,591.88	2,238.66	1,421.31	1,701.50		46,468.33
Idaho	185.65	1,113.88	324.88	556.94	696.18	1,624.47	603.45	2,459.84	696.18	12,181.02	54,416.56
Illinois	1,208.52	7,254.90	2,115.38	3,625.57	4,532.43	12,767.74	6,878.69				435,852.95
Indiana	2,220.86	10,555.87	5,938.26	9,692.74	2,735.70	24,123.56	7,673.38	11,808.60	1,638.41	376,334.20	958,534.10
Iowa		5,093.67	1,402.42	3,704.71	2,768.42	10,595.58	1,031.82	14,554.31	5,474.35	15,696.92	292,066.89
Kansas	312.27	10,599.66	3,628.60	2,822.93	2,476.68	4,152.32	576.62	9,882.93	2,000.00	21,818.25	188,863.78
Kentucky	1,880.56	2,472.99	6,002.01	2,220.71	1,973.75	10,188.58	4,406.84	32,244.99	5,600.28	4,274.91	306,448.77
Louisiana	98.60	4,086.52	1,055.67	860.37	5,692.15	3,603.26	933.74	5,894.39	86.90	7,306.27	121,072.18
Maine	294.98	2,039.01	215.56	1,223.20	156.55	1,611.55	142.83	1,822.93		2,844.91	65,105.02
Maryland	201.13	2,067.65	122.63	340.85	1,321.63	2,608.12	1,783.71	2,046.10	2,085.00	11,664.64	103,233.15
Massachusetts	267.37	2,490.86	1,435.77	2,152.00		8,185.12	261.86	452.77	123.07	78,816.71	290,076.94
Michigan	1,282.03	9,319.40	1,316.95	3,737.08	2,428.27	11,779.28	2,641.53	3,097.39	876.66		268,676.13
Minnesota	2,398.75	14,323.71	2,231.28	3,453.42	2,990.77	6,616.75	4,081.61	17,312.93			421,088.48
Mississippi	440.86	10,068.77	1,703.69	46.74	3,271.25	6,025.69	229.69	18,709.56		72,949.83	231,444.11
Missouri	315.60	3,837.28	984.65	2,100.71	1,448.80	3,154.59	1,493.71	3,998.75	2,435.00	37,608.25	167,971.52
Montana	77.80	4,884.37	154.82	122.04	425.00	2,943.33	157.00	1,191.97		22,426.68	149,774.89
Nebraska	623.16	4,793.29	3,536.93	5,092.82	9,200.57	2,089.97	1,793.36	2,626.56	360.38		202,245.19

TABLE 10.—*Expenditures from supplementary funds received from within the States for the year ended June 30, 1937*—Continued

Station	Library	Tools, implements, and machinery	Furniture and fixtures	Scientific apparatus	Livestock	Travel	Contingent	Buildings	Land	Balance	Total
Nevada	229.10		103.05			1,198.22	955.96	307.00		6,498.53	10,019.51
New Hampshire	17.98	176.83	742.62	444.61	112.04	2,667.37	695.12	437.04		21,402.02	51,591.08
New Jersey	838.42	17,142.94	189.30	1,152.17		12,676.38	14,777.53	1,429.29	528.50	4,482.62	459,982.25
New Mexico	209.84	423.36	66.11	118.75	225.00	530.12	558.63	102.92		35,655.38	55,772.04
New York:											
Cornell	2,436.54	7,951.65	4,050.23	19,366.15	893.09	25,612.95	4,748.51	5,938.52			646,079.34
State	1,136.00	49.65			200.00	2,999.87	1,109.92	9,575.01		126,733.80	379,536.39
North Carolina	11.42	4,178.93	269.80	299.02	2,659.77	6,782.27	8,004.79	18,238.43	75.75	2,729.85	143,646.17
North Dakota	244.68	1,597.45	456.91	425.62	886.41	3,001.59	5,964.86	3,582.55		2,138.19	84,748.51
Ohio	838.83	15,228.47	1,390.14	1,310.35	6,076.69	6,066.68	4,072.44	16,103.15	12,361.08	164,209.64	662,669.18
Oklahoma	947.30	1,719.49	578.43	1,676.08	10,380.24	4,112.31	6,893.17	12,483.78		20,439.29	161,639.80
Oregon	205.15	8,580.40	804.68	1,702.36	17,953.92	8,593.88	5,117.05	2,700.16	4,999.53	190,192.47	423,786.16
Pennsylvania	311.41	1,557.19	495.40	808.81	990.53	8,975.87		3,435.04	933.37	4,186.32	172,210.32
Puerto Rico	884.49	1,912.67	579.38	2,949.50	125.00	2,129.81	2,191.16	6,076.62		3,172.27	136,447.44
Rhode Island	74.32	354.70	52.91	354.97	20.00	390.40	17.64	326.90		2,054.91	9,816.41
South Carolina	97.66	10,323.24	3,320.41	1,744.48	6,019.32	2,655.62	3,074.32	21,539.06	11,223.68	8,166.04	183,344.23
South Dakota	132.47	381.27	297.09	768.24	3,161.29	1,402.48	73.32	824.23		19,550.36	55,955.72
Tennessee	64.12	3,091.76	538.37	94.50	1,528.54	607.94	1,346.26	10,522.40	95.00		61,807.77
Texas	1,304.94	7,899.14	2,726.61	2,832.33	7,283.75	22,107.26	46,830.01	3,979.72	2,267.53	76,616.81	589,103.58
Utah	559.30	1,079.93	2,163.99	18.25	750.45	3,563.79	460.55	848.23	3,123.62	4,510.78	57,051.30
Vermont	150.18	219.79	77.30	28.89		1,827.03	52.27	299.65		541.49	25,931.22
Virginia	759.54	988.51	462.68	836.26	506.30	5,492.83	266.51	3,597.44	200.00	387.59	97,818.95
Washington	969.74	4,589.98	1,231.58	2,294.98	780.80	3,718.61		8,652.79			125,223.45
West Virginia		2,065.24		2,194.17	280.00	2,306.60	3,171.23	1,240.60		13,558.46	114,107.88
Wisconsin	1,078.58	8,026.14	954.90	8,326.27	3,114.10	9,121.37	16,536.63	6,050.95			414,186.00
Wyoming	493.78	2,469.07	790.28	1,283.89	1,580.36	1,396.39				61,337.07	127,383.64
Total	38,349.65	284,043.04	79,338.37	123,875.00	140,231.44	338,859.92	194,240.17	404,522.98	83,122.53	1,715,221.87	12,074,252.72

TABLE 11.—*Experiment station expenditures for additions to equipment for the year ended June 30, 1937*

Station	Buildings	Library	Apparatus	Farm implements	Livestock	Total
Alabama	$11,326.87	$725.84	$3,946.75	$5,399.69	$7,069.38	$28,468.53
Alaska	422.90	12.13	69.95	518.81	32.50	1,056.29
Arizona	1,393.20	18.45	2,530.60	4,395.14	----------	8,337.39
Arkansas	2,656.36	1,097.29	5,975.10	12,622.26	642.63	22,993.64
California	50,834.74	3,836.58	11,509.75	23,019.50	14,387.19	103,587.76
Colorado	12,466.88	514.63	4,971.74	8,208.30	4,176.12	30,337.67
Connecticut:						
State	5,965.24	2,132.04	1,188.28	5,946.42	107.75	15,339.73
Storrs	----------	1,155.22	2,538.20	1,216.59	281.25	5,191.26
Delaware	2,254.11	1,433.83	2,500.64	1,392.86	321.77	7,903.21
Florida	45,393.43	2,760.29	10,797.46	28,535.93	5,141.83	92,628.94
Georgia	10,029.38	1,347.55	3,296.53	3,748.02	3,153.35	21,574.83
Hawaii	1,421.31	315.09	5,140.17	1,700.93	785.13	9,362.63
Idaho	3,071.52	266.09	3,116.77	1,184.75	814.18	8,453.31
Illinois	----------	1,239.51	11,505.06	9,637.22	4,532.43	26,914.22
Indiana	12,618.77	2,220.86	21,790.77	10,848.82	2,874.00	50,353.22
Iowa	14,554.31	----------	4,731.36	6,121.72	2,768.42	28,175.81
Kansas	13,426.94	327.27	5,101.79	11,169.96	3,546.27	33,572.23
Kentucky	40,335.91	1,922.56	4,158.10	2,545.71	1,982.25	50,944.53
Louisiana	5,894.39	112.02	3,141.94	4,842.90	6,042.35	20,033.60
Maine	1,822.93	1,005.57	2,121.85	3,321.81	884.70	9,156.86
Maryland	2,046.10	218.08	2,062.19	2,898.53	1,871.73	9,096.63
Massachusetts	452.77	421.51	3,092.90	2,498.72	101.30	6,567.20
Michigan	3,097.39	1,314.18	5,751.59	9,739.78	2,429.27	22,332.21
Minnesota	17,312.93	2,411.99	7,011.44	15,285.86	4,618.33	46,640.55
Mississippi	18,764.86	547.75	2,279.34	12,864.98	5,161.82	39,618.75
Missouri	4,178.75	508.42	6,724.74	6,604.64	3,621.16	21,637.71
Montana	1,191.97	610.97	1,406.18	5,820.08	500.00	9,529.20
Nebraska	2,626.56	708.46	9,373.92	4,840.92	9,384.52	26,934.38
Nevada	509.60	439.37	274.53	1,451.43	1,963.53	4,638.46
New Hampshire	437.04	722.96	1,935.71	571.42	175.49	3,842.62
New Jersey	1,451.79	1,461.64	4,837.64	19,214.38	58.50	27,023.95
New Mexico	476.78	343.32	1,988.53	1,375.88	1,849.15	6,033.66
New York:						
Cornell	7,896.71	2,555.47	21,085.04	8,431.52	898.09	40,866.83
State	----------	1,136.00	----------	49.65	200.00	1,385.65
North Carolina	18,238.48	27.02	3,050.38	5,348.61	2,818.25	29,482.74
North Dakota	3,582.55	307.20	1,084.45	2,006.11	4,026.44	11,000.75
Ohio	8,673.26	853.75	2,205.32	18,237.56	12,880.53	42,850.42
Oklahoma	15,758.11	968.53	9,430.50	4,554.71	11,476.26	42,188.11
Oregon	2,700.16	272.68	2,747.54	8,690.99	17,955.92	32,365.29
Pennsylvania	12,888.38	311.41	6,237.79	4,829.97	1,290.43	25,557.98
Puerto Rico	6,076.62	945.59	5,103.52	2,073.64	182.00	14,781.37
Rhode Island	326.90	450.53	658.66	2,577.11	20.00	4,033.20
South Carolina	24,893.12	1,212.72	4,637.44	11,553.71	6,019.32	48,316.31
South Dakota	824.23	669.81	5,782.37	1,176.09	3,571.29	12,023.79
Tennessee	18,817.21	777.04	1,597.16	4,634.24	1,538.54	27,364.19
Texas	4,523.04	1,623.90	8,920.45	8,233.27	7,563.75	30,864.41
Utah	848.23	728.13	1,854.17	1,832.23	763.61	6,026.37
Vermont	586.60	349.80	2,208.08	954.84	116.00	4,215.32
Virginia	7,010.56	812.63	5,042.34	1,721.56	514.30	15,101.39
Washington	7,439.24	1,332.84	3,264.86	5,101.50	2,025.05	19,163.49
West Virginia	1,240.60	19.64	4,722.20	3,565.33	1,376.49	10,924.26
Wisconsin	6,050.95	1,078.58	8,326.27	8,026.14	3,114.10	26,596.04
Wyoming	----------	621.83	2,682.77	3,311.68	2,035.81	8,652.09
Total	436,810.68	49,206.57	257,912.83	336,448.42	171,662.48	1,252,040.98

TABLE 12.—*Disbursements from the U. S. Treasury to the States and Territories and Puerto Rico for agricultural experiment stations under the acts of Congress approved Mar. 2, 1887, Mar. 16, 1906, Feb. 24, 1925, May 16, 1928, Feb. 23, 1929, and June 29, 1935*

State or Territory	Hatch Act		Adams Act		Purnell Act		Bankhead-Jones Act	
	1888–1936	1937	1906–36	1937	1926–36	1937	1936	1937
Alabama	$733,946.42	$15,000.00	$431,619.89	$15,000.00	$560,000.00	$60,000.00	$20,673.78	$41,347.56
Alaska	75,000.00	15,000.00					559.12	1,118.24
Arizona	699,803.10	15,000.00	434,955.61	15,000.00	560,000.00	60,000.00	3,105.64	6,211.28
Arkansas	733,139.12	15,000.00	434,900.00	15,000.00	560,000.00	60,000.00	15,995.80	31,991.60
California	735,000.00	15,000.00	434,926.84	15,000.00	560,000.00	60,000.00	16,485.49	32,970.98
Colorado	734,718.82	15,000.00	433,638.93	15,000.00	560,000.00	60,000.00	5,607.74	11,215.48
Connecticut	735,000.00	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	5,164.52	10,329.04
Dakota Territory	56,250.00							
Delaware	733,382.87	15,000.00	430,475.12	15,000.00	556,924.01	60,000.00	1,252.55	2,505.10
Florida	734,966.04	15,000.00	434,996.06	15,000.00	556,523.74	60,000.00	7,700.41	15,400.82
Georgia	730,593.43	15,000.00	422,092.87	15,000.00	560,000.00	60,000.00	21,880.73	43,761.46
Hawaii	104,919.17	15,000.00	59,951.14	15,000.00		20,000.00	2,296.60	4,593.20
Idaho	659,324.13	15,000.00	430,842.22	15,000.00	560,000.00	60,000.00	3,429.64	6,859.28
Illinois	734,196.55	13,967.88	434,794.91	15,000.00	557,445.71	60,000.00	21,684.13	43,059.48
Indiana	734,901.19	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	15,680.65	29,123.83
Iowa	735,000.00	15,000.00	435,000.00	15,000.00	557,965.17	60,000.00	16,213.66	32,427.32
Kansas	734,995.00	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	12,512.74	25,025.48
Kentucky	734,996.57	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	19,734.51	39,469.02
Louisiana	735,000.00	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	13,783.36	27,566.72
Maine	734,999.62	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	5,173.04	10,346.08
Maryland	734,967.40	15,000.00	434,236.48	15,000.00	560,000.00	60,000.00	7,137.62	14,275.24
Massachusetts	734,617.70	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	4,545.55	9,091.10
Michigan	734,676.10	15,000.00	431,341.20	15,000.00	560,000.00	60,000.00	16,741.96	33,483.92
Minnesota	734,917.78	15,000.00	434,345.00	15,000.00	560,000.00	60,000.00	14,199.41	28,398.82
Mississippi	735,000.00	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	18,162.85	36,325.70
Missouri	730,097.24	15,000.00	434,999.90	15,000.00	560,000.00	60,000.00	19,241.95	38,483.90
Montana	645,000.00	15,000.00	432,417.04	15,000.00	560,000.00	60,000.00	3,875.79	7,751.58
Nebraska	734,932.16	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	9,694.15	19,388.30
Nevada	734,214.32	15,000.00	433,180.28	15,000.00	560,000.00	60,000.00	615.16	1,230.32
New Hampshire	735,000.00	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	2,089.30	4,178.60
New Jersey	734,949.97	15,000.00	434,392.06	15,000.00	560,000.00	60,000.00	7,631.46	15,262.92
New Mexico	699,509.05	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	3,440.25	6,880.50
New York	734,757.18	15,000.00	434,187.18	15,000.00	560,000.00	59,904.18	22,457.91	44,915.70
North Carolina	735,000.00	15,000.00	435,000.00	15,000.00	560,000.00	60,000.00	25,657.00	51,314.00
North Dakota	676,502.26	15,000.00	434,638.85	15,000.00	560,000.00	59,994.14	6,168.94	12,337.87
Ohio	735,000.00	15,000.00	433,514.02	15,000.00	560,000.00	60,000.00	23,253.69	46,507.38
Oklahoma	659,002.16	15,000.00	414,535.19	15,000.00	560,000.00	60,000.00	17,112.71	34,225.42
Oregon	720,156.64	15,000.00	430,000.00	15,000.00	560,000.00	60,000.00	5,043.95	10,087.90
Pennsylvania	734,967.43	15,000.00	434,995.41	15,000.00	560,000.00	60,000.00	33,672.38	67,344.76
Puerto Rico	29,950.17	14,872.57	22,390.51	12,913.66		5,000.00	12,138.04	21,165.18
Rhode Island	735,000.00	14,999.65	429,520.20	14,903.30	560,000.00	59,974.75	565.96	1,131.92

South Carolina	734, 542. 15	15, 000. 00	433, 460. 12	15, 000. 00	560, 000. 00	60, 000. 00	14, 866. 24	29, 732. 48
South Dakota	678, 250. 00	15, 000. 00	430, 000. 00	15, 000. 00	560, 000. 00	60, 000. 00	6, 108. 11	12, 216. 22
Tennessee	735, 000. 00	15, 000. 00	435, 000. 00	15, 000. 00	560, 000. 00	60, 000. 00	18, 695. 97	37, 391. 94
Texas	735, 000. 00	15, 000. 00	432, 592. 26	15, 000. 00	560, 000. 00	60, 000. 00	37, 341. 19	74, 682. 38
Utah	600, 000. 00	15, 000. 00	434, 821. 94	15, 000. 00	560, 000. 00	60, 000. 00	2, 625. 92	5, 251. 84
Vermont	735, 000. 00	15, 000. 00	435, 000. 00	15, 000. 00	560, 000. 00	60, 000. 00	2, 617. 90	5, 235. 80
Virginia	732, 824. 12	15, 000. 00	434, 949. 01	15, 000. 00	559, 994. 27	60, 000. 00	17, 786. 14	35, 572. 28
Washington	672, 102. 65	15, 000. 00	431, 080. 11	15, 000. 00	560, 000. 00	60, 000. 00	7, 378. 93	14, 757. 86
West Virginia	734, 795. 53	15, 000. 00	432, 013. 85	14, 999. 97	559, 942. 89	60, 000. 00	13, 453. 36	26, 906. 72
Wisconsin	735, 000. 00	15, 000. 00	435, 000. 00	15, 000. 00	560, 000. 00	60, 000. 00	15, 056. 22	30, 112. 44
Wyoming	720, 000. 00	15, 000. 00	435, 000. 00	15, 000. 00	560, 000. 00	60, 000. 00	1, 689. 88	3, 379. 76
Total	34, 870, 864. 04	763, 840. 10	20, 875, 804. 20	747, 816. 93	26, 868, 795. 79	2, 904, 873. 07	600, 000. 00	1, 194, 342. 72

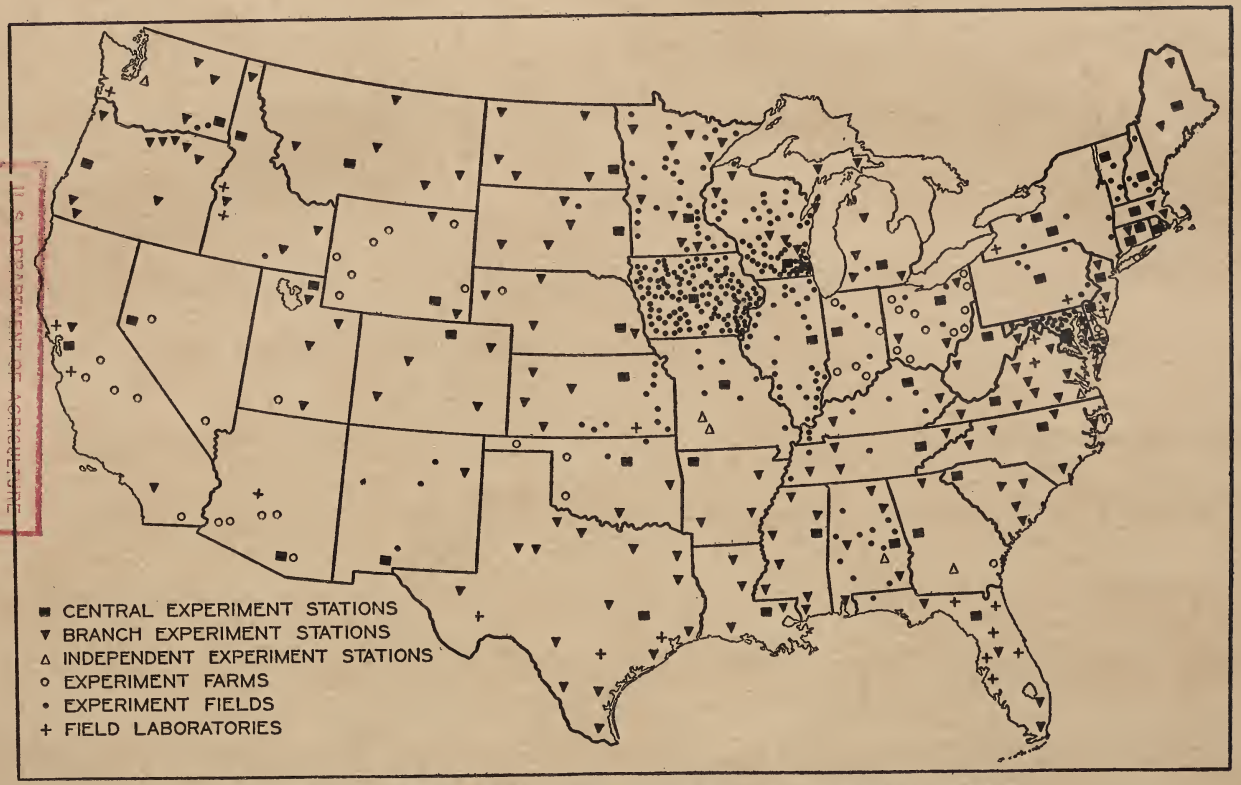
INDEX

U. S. GOVERNMENT PRINTING OFFICE: 1938

ADDRESS LIST OF AGRICULTURAL EXPERIMENT STATIONS

ALABAMA.—*Auburn,* M. J. Funchess, Director.
ALASKA.—*College,* L. T. Oldroyd, Director.
ARIZONA.—*Tucson,* R. S. Hawkins, Acting Director.
ARKANSAS.—*Fayetteville,* Dan T. Gray, Director.
CALIFORNIA.—*Berkeley,* C. B. Hutchison, Director.
COLORADO.—*Fort Collins,* E. P. Sandsten, Director.
CONNECTICUT.—*New Haven,* W. L. Slate, Director; *Storrs,* W. L. Slate, Director.
DELAWARE.—*Newark,* C. A. McCue, Director.
FLORIDA.—*Gainesville,* Wilmon Newell, Director.
GEORGIA.—*Experiment,* H. P. Stuckey, Director.
HAWAII.—*Honolulu,* L. A. Henke, Acting Director.
IDAHO.—*Moscow,* E. J. Iddings, Director.
ILLINOIS.—*Urbana,* J. C. Blair, Director.
INDIANA.—*La Fayette,* J. H. Skinner, Director.
IOWA.—*Ames,* R. E. Buchanan, Director.
KANSAS.—*Manhattan,* L. E. Call, Director.
KENTUCKY.—*Lexington,* T. P. Cooper, Director.
LOUISIANA.—*University,* C. T. Dowell, Director.
MAINE.—*Orono,* F. Griffee, Director.
MARYLAND.—*College Park,* J. E. Metzger, Acting Director.
MASSACHUSETTS.—*Amherst,* F. J. Sievers, Director.
MICHIGAN.—*East Lansing,* V. R. Gardner, Director.
MINNESOTA.—*University Farm, St. Paul,* W. C. Coffey, Director.
MISSISSIPPI.—*State College,* Clarence Dorman, Acting Director.
MISSOURI.—*Columbia,* F. B. Mumford, Director.
MONTANA.—*Bozeman,* Clyde McKee, Director.
NEBRASKA.—*Lincoln,* W. W. Burr, Director.
NEVADA.—*Reno,* S. B. Doten, Director.
NEW HAMPSHIRE.—*Durham,* J. C. Kendall, Director.
NEW JERSEY.—*New Brunswick,* J. G. Lipman, Director.
NEW MEXICO.—*State College,* Fabian Garcia, Director.
NEW YORK.—*Geneva* (State Station), P. J. Parrott, Director; *Ithaca* (Cornell Station), C. E. Ladd, Director.
NORTH CAROLINA.—*State College Station, Raleigh,* I. O. Schaub, Acting Director.
NORTH DAKOTA.—*State College Station, Fargo,* H. C. Hanson, Director.
OHIO.—*Wooster,* Edmund Secrest, Director.
OKLAHOMA.—*Stillwater,* L. S. Ellis, Acting Director.
OREGON.—*Corvallis,* W. A. Schoenfeld, Director.
PENNSYLVANIA.—*State College,* R. L. Watts, Director.
PUERTO RICO.—*Mayaguez,* Atherton Lee, Director.
RHODE ISLAND.—*Kingston,* P. S. Burgess, Director.
SOUTH CAROLINA.—*Clemson,* H. P. Cooper, Director.
SOUTH DAKOTA.—*Brookings,* I. B. Johnson, Director.
TENNESSEE.—*Knoxville,* C. A. Mooers, Director.
TEXAS.—*College Station,* A. B. Conner, Director.
UTAH.—*Logan,* R. H. Walker, Director.
VERMONT.—*Burlington,* J. L. Hills, Director.
VIRGINIA.—*Blacksburg,* A. W. Drinkard, Jr., Director.
WASHINGTON.—*Pullman,* E. C. Johnson, Director.
WEST VIRGINIA.—*Morgantown,* C. R. Orton, Director.
WISCONSIN.—*Madison,* C. L. Christensen, Director.
WYOMING.—*Laramie,* J. A. Hill, Director.

NOTE.—The full official titles, locations, and personnel of the agricultural experiment stations will be found in the list of Workers in Subjects Pertaining to Agriculture in Land-Grant Colleges and Experiment Stations, published annually by the United States Department of Agriculture.



LOCATIONS OF STATE EXPERIMENT STATIONS, SUBSTATIONS, AND EXPERIMENTAL FIELDS.